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ABSTRACT

This handbook was designed to assist practicing vocational educators in planning and preparing performance measures for evaluating the behavioral outcomes of instruction. It is particularly concerned with fulfilling the needs of individuals involved in manpower development and training programs. The nature of and need for performance testing is discussed. Various stages in the development of a work-sample performance test are delineated, and alternative approaches to performance testing, including the paper-and-pencil test, are comparatively considered. Attention is given to the advantages and disadvantages of each type of testing. The appendix covers a wide range of skills and occupations in its sampling of performance tests, most of which are accompanied by identifying information and instructions for administration and scoring. An extensive bibliography is included. (PR)

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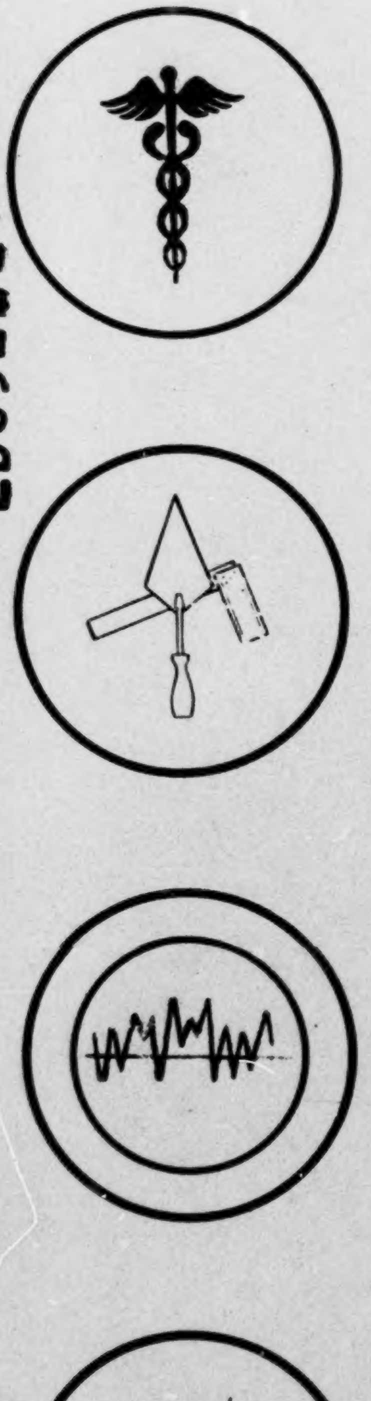

HANDBOOK OF PERFORMANCE TESTING

A PRACTICAL GUIDE FOR TEST MAKERS

by
Joseph L. Boyd, Jr.
and
Benjamin Shimberg

Educational Testing Service
Princeton, New Jersey

January 1970

TM 000 493

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HANDBOOK
OF
PERFORMANCE TESTING

A Practical Guide for Test Makers

By

Joseph L. Boyd, Jr.
Benjamin Shimberg

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Educational Testing Service
Princeton, New Jersey 08540

January 1971

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CHAPTER I

INTRODUCTION TO PERFORMANCE TESTING

Since World War I, testing specialists have made great advances in measuring both aptitude and achievement by means of paper-and-pencil tests. A multimillion dollar industry has been built on the ability of such tests to predict with reasonable accuracy the future success of students in elementary and secondary school, in college, and in professional schools. Written tests have also been used to screen applicants for apprenticeship and other types of training programs and to identify workers who are most likely to be successful on the job.

By contrast, performance testing has been largely neglected. The efficiency and economy of paper-and-pencil testing made it attractive to educators and to employers--written tests could be given to large groups at a single sitting, and the answer sheets could be scored electronically. Performance tests, on the other hand, almost always have to be given on an individual basis. Such tests take longer to administer, and the scoring cannot be done as quickly or as economically.

It is not surprising that those involved in training people for skilled occupations would look to paper-and-pencil tests as a convenient method of evaluating achievement. For many years the belief was widely held that there was a high relationship between trade information and performance and that the former could serve as an indirect measure of the latter. This idea may have gained currency in an era when research showed a generally high correlation between written tests and final course grades. Such grades were accepted uncritically as valid indicators of overall proficiency. What was often overlooked, however, was the fact that the course grades were themselves often based on written tests; thus it was not surprising to find written tests of trade knowledge showing a high relationship with such grades. However, when special attention was given to assessing shop performance and

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when such performance was given appropriate weighting in the final grade, the relationship tended to go down substantially. Writing about the Navy's experience with performance measures during World War II, Stuit (1947) says, "Although it had been assumed that written test sufficed to indicate what a man had learned in a service school, the evidence showed that performance tests and improved shop grades were not closely correlated with written test grades. During tryout in a gunners' mate school, performance tests correlated from .14 to .35 with written tests and only slightly higher with final grades which were based largely on written tests. In a torpedoman school where shop grading was quite good, test tryouts showed that, on the average, their sample performance tests correlated .63 with final grades, but only .38 with the multiple-choice final examination." (p. 306)

Today it is generally conceded that written tests of trade knowledge are not a very dependable way to evaluate shop performance and that without some type of direct or indirect measure of actual performance it is unlikely that we can make an accurate assessment of an individual's trade competency.

Unfortunately, the attention of measurement specialists continues to be focused on paper-and-pencil tests to the virtual neglect of the performance testing field. Thus, even if one is convinced of the desirability of preparing performance tests and has the motivation to embark on such a venture, he is likely to find little help in the voluminous literature on the subject of testing. An excellent overview of the subject was prepared by Ryans and Fredericksen in 1951, as a chapter in *Educational Measurement*, edited by E. F. Lindquist. Fitzpatrick and Morrison have updated this early summary for a new edition of *Educational Measurement* which is to be published during 1971 by the American Council on Education. While both of these reports are useful in describing the "state of the art," they tend to be too general to be of much assistance to the vocational educator who

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seeks specific and practical guidance in preparing performance tests for use with his students.

The present *Handbook* was conceived as a tool that practicing vocational educators would find useful in planning and preparing performance measures for evaluating the behavioral outcomes of instruction. Since funding for the project has been derived from a government agency concerned with manpower development and training programs, the needs of individuals involved in such programs have been uppermost in the minds of the authors. However, the sponsors of this project have encouraged the authors to explore the subject of performance evaluation broadly and to draw illustrations from diverse sources so that the material presented in the *Handbook* would be of value to all educators concerned with occupational education.

In assembling the material for this *Handbook*, the authors have drawn upon a variety of published and unpublished sources. They have visited a number of military installations which are using performance tests to evaluate the outcomes of instruction. They have also talked with licensing officials at local, state, and national levels to ascertain how these agencies conduct performance evaluations of applicants for licensure in such occupations as airplane mechanics, plumbing, cosmetology, and dental hygiene.

It was never the intention of the authors to present the results of their literature search or field visits in detail. While such a report might serve some scholarly purpose, it would not be likely to meet the need of the practitioner who desires down-to-earth help with respect to developing practical performance tests or evaluating the outcomes of such tests. Moreover, the authors have not set themselves the task of preparing a multipurpose cookbook that anyone might be able to follow in preparing performance tests. The approach taken is somewhat more general. On the one hand, it deals with certain fundamental concepts that underlie all types of performance measures; at the same time, it underscores the need for flexibility and diversity by pointing out the many different approaches that have been taken by test developers in solving their unique problems. It is hoped that these examples and case studies will encourage vocational educators to think creatively and to adapt the material presented to their own fields. What matters primarily is not the specifics, but the approach and the point of view. If the reader can grasp these, he will be well on his way toward building worthwhile performance measures tailored to his own situation.

CHAPTER II

WHY MEASURE PERFORMANCE?

Measuring performance is nothing new. For centuries it has been done informally by those responsible for transmitting skills to others--by teachers in schools, by craftsmen responsible for the training of apprentices, and by foremen in industry. At times the "test" has taken the form of a written exercise, such as a set of arithmetic problems or a spelling quiz. More often, however, it has involved the actual demonstration of a skill in a realistic setting, usually on the actual equipment of the trade involved.

Today we take it for granted that somebody has checked out the competence of the pilot who flies our jetliner to California, the plumber who repairs a broken water line, and the cosmetologist who gives permanent waves. None of us would be very comfortable flying at 600 miles an hour if we thought that the pilot had been examined *only* on a written test. Nor would the women who patronize beauty salons submit so cheerfully to the scissors, curlers, and chemicals of the cosmetologist if they thought her competence had been demonstrated only to the extent necessary to answer some questions on a multiple-choice test.

Most of us recognize that there is a fundamental difference between *knowing about* a job and being able to *do* the job. "Knowledge of" is really an essential ingredient for doing a complex job correctly, but while it is a *necessary* condition, it is rarely a *sufficient* condition for satisfactory performance. During World War II, the U.S. Office of Education hired a high school English teacher to edit material relating to welding. He soon became the greatest "paper welder" in the world. He knew the vocabulary of welding, which gases were best for which purposes, and the merits of every type of equipment used in the trade. He could talk a "great game" and would probably have made an impressive score on any written test *about* welding. Unfortunately, he had never held a welding torch in his hands and he would have been at a complete loss had he been ordered to do even a simple weld.

A person may be able to bluff on a written test, but he can seldom carry off a successful deception when a realistic performance test is required. This is one of the great virtues of the performance test. It has impressive "face validity" and credibility because the task one must do so closely resembles the job itself. Frequently the performance test is nothing more than a work sample--requiring doing an actual task, but outside of the normal job environment. To save time, one may require the individual to do only part of the job, but the assignment is likely to be one calling for a relatively high degree of skill. Thus the person being tested in the machine trades might be given a partially finished part and a blueprint and be instructed to machine it to specified dimensions.

It is often impractical to reproduce a real job situation or to provide actual equipment. However, critical job elements can be simulated in a laboratory or in a "black box." Thus an electronic technician may be required to check out circuits and to identify and repair malfunctions on a piece of simulated equipment. Some of the reality of the work setting may be sacrificed, but the critical job elements--namely the wiring of the components that are found in complex electronic equipment--are present; thus, the test is readily recognized as a realistic representation of the tasks one would encounter on the job. One should not think of simulation situations as necessarily divorced from the stimuli normally associated with the actual work situation. A bridge simulator used for training and testing deck officers in the merchant marine utilizes motion pictures to provide the subject with visual cues--such as the shoreline, buoys, lights, and markers that he would normally see were he on the bridge of a ship. A new test for automotive mechanics has made use of stereophonic recordings of the sounds one hears when certain parts of the engine or the transmission are malfunctioning.

While most developers of performance tests strive to retain an element of reality by creating work samples or simulators, there are times when reality must be sacrificed in the interest of efficiency or in the interest of measuring certain mental processes that cannot be measured conveniently in any other way. One such invention is the "tab test." The examinee is presented with a job-like situation--such as a description of a malfunction in a piece of electronic equipment--and he is required to specify the sequence in which he would "troubleshoot" in order to identify and repair the malfunction. The "tab test" introduces an element of reality--without introducing the actual equipment--by providing feedback in the form of information. Each time that the examinee decides to check a part, he pulls a tab. Underneath the tab (on a separate sheet) he learns the results of his test. A skilled technician will isolate the likely source of the trouble and zero in on the malfunction rather quickly, pulling a minimum number of tabs in the process. A less skilled individual may go through a considerable amount of trial-and-error testing. Although he may eventually isolate the trouble, he will have pulled many more tabs in the process. Interestingly, although this type of test was originally developed for electronic technicians, it has been found to be a useful device for assessing the diagnostic skill of physicians.

While the advantages of hands-on performance testing are recognized by most educators, the disadvantages have proved to be a decisive deterrent. Most performance tests are devised to be given on a one-to-one basis. Rarely does a vocational educator have the resources of the Chrysler Motors Corporation to conduct his own version of the Plymouth troubleshooting contest where cars are available to be worked on simultaneously by teams of mechanics. Equipment limitations often require that a test be given over a period of time. This can be a time-consuming and expensive procedure. Moreover, the security of the test may be compromised if those who take it early pass along vital information to those who are scheduled to take it at a later time. Sometimes this will not materially influence the outcome; at other times it may completely invalidate the results.

Despite these drawbacks, educators should recognize that performance testing is an essential ingredient of any evaluation program. A paper-and-pencil test may be easier to develop and quicker to administer and score. However, it is rarely an adequate substitute for a good performance measure. Indeed, the exclusive use of paper-and-pencil tests to evaluate students in vocational programs can have an undesirable impact on learning. Some shop instructors unwittingly downgrade the importance of performance by basing their evaluation of shop work on casual observations that result in nearly everyone's receiving a "satisfactory" rating on this aspect of the course. They may then use written tests to measure knowledge about the course. Since there may be considerable variability among the students on the written test, this test will, in effect, have a greater weight in determining the final grade than it deserves. Thus students may be motivated to study for the written test rather than to put forth special efforts to master the performance aspects of the occupation.

Good performance measures help to overcome this undesirable situation. The student knows that his overall grade will be greatly influenced by the way in which he carries out the performance task. He knows that he may be judged not only by the end-product, but also by the manner in which he does his work. This will motivate him to pay more attention to detail, for he knows that on a well-developed performance test the examiner will be looking for those elements that differentiate the skilled craftsman from the incompetent or sloppy worker. Evaluations that include appropriate performance testing as well as written examinations will usually result in a more dependable overall course grade than either type of evaluation used alone. However, if a choice has to be made, greater emphasis should be given to measuring the individual's ability to do the job than to his knowledge about the job.

The teacher who accepts the foregoing line of reasoning and wishes to improve his skills in developing performance tests will find many practical suggestions in the body of this *Handbook* and in the portfolio of sample examinations included in the appendix.

Since the range of situations that vocational educators may wish to evaluate is almost infinite, it would be impractical to provide universally applicable guidelines. In this *Handbook* the authors have tried to illustrate the various steps one should follow by drawing on examples which are intrinsically interesting and meaningful and which illustrate the points under discussion. In some instances the examples are a bit dated, but nonetheless seem to illustrate a point the authors wished to make better than any of the more recent material that was available. We hope that new material can be included in future editions. The suggestions and assistance of readers will be welcomed.

CHAPTER III

PLANNING THE PERFORMANCE TEST

Whether one sets out to develop a written test or a performance test, the first--and usually the most difficult--task is deciding what should be covered. If the course objectives have been stated in behavioral terms, the critical behaviors appropriate to a given level of training may be identified and used as a basis for developing the test specifications. Certain of the objectives may lend themselves to testing by means of a paper-and-pencil test. This approach is the most economical and most efficient. It should be used whenever it is feasible to do so. Many performance-type problems can be presented in this format. The results will enable the instructor to ascertain rather quickly whether or not the student has mastered these objectives of instruction.

More will be said about paper-and-pencil performance tests later in this chapter. For the present, however, there is greater concern about those objectives that do not lend themselves to a paper-and-pencil format. One wants to find out whether the student can do a given task and meet certain performance standards. For such situations one needs to identify performance objectives and to devise techniques for measuring these objectives.

It is worth noting that performance objectives are generally derived from a careful job analysis. At the risk of belaboring the obvious, it may be worthwhile to review the procedure one follows in moving from a job analysis to the determination of instructional objectives, for the same general process should guide the selection of tasks for inclusion in a standardized performance test.

There are many ways to conduct a job analysis, but it is not the purpose of this *Handbook* to review them. Often the test writer has an intimate knowledge of the job and can prepare an adequate description on the basis of his own experience. It is generally a good idea to have others review and verify the description. Workers can be observed as they perform their jobs and a record made of their activities. This technique works best for short, repetitive jobs. Workers may also be called upon to describe their jobs either in an interview situation or by the use of a questionnaire. One such questionnaire is shown in Figure 1. It was used to survey the duties of a dental hygienist. Note that it includes information about the frequency with which each person performed a task, when the task was first performed, the degree to which it was supervised, and how critical it is for proper job performance.

Job descriptions vary from the very detailed and elaborate to the relatively simple. Figure 2 illustrates a detailed job analysis of an engine lathe operator, first class, working in an aircraft plant. The analysis includes information about training; responsibility; job knowledge; mental application; dexterity and accuracy; and equipment, material, and supplies. Such detailed analyses can be very helpful in planning instruction or in developing evaluation instruments, but often a simpler approach will suffice. A less detailed job description is shown in Figure 3. Although simple, it is quite adequate as a starting point for developing a performance test.

Whether one starts with a job analysis or with behavioral objectives which were originally derived from such an analysis, one must decide which elements of the job are crucial to success. It is from among these critical job elements that one should select the tasks to be used as a measure of job performance. Because performance testing is generally a slow and time-consuming process, only a few of the critical job elements can be included. One must decide which ones are really crucial. In using this criterion one assumes that if an individual is able to perform the most critical tasks in a satisfactory manner, it is highly probable that he could do equally well on other tasks which are less critical. Thus, in examining plumbers for licensing, boards frequently require the candidate to join two pieces of pipe by "pouring" or "wiping lead." Many years ago this was probably the hallmark of the highly skilled craftsman. Unfortunately, the practice of testing this skill has

FIGURE 1 QUESTIONNAIRE TO SURVEY JOB OF ARMY DENTAL HYGIENISTS

Definition of Terms

"SAMPLE QUESTIONNAIRE"

TASKS PERFORMED	FREQUENCY OF PERFORMANCE			WHEN FIRST PERFORMED				IS IT SUPERVISED			HOW CRITICAL	
	Never	Some time	Often	0-3 Mo.	3-6 Mo.	6-12 Mo.	Over 1 Yr	Never	Some time	Always	Must Know	Nice to Know
/ / / / / / PATIENT EDUCATION / / / / / / / / / / /	/ / /	/ / /	/ / /	/ /	/ /	/ /	/ / /	/ / /	/ / /	/ / /	/ / /	/ / / /
resent individual instruction on preventive dentistry			✓	✓						✓	✓	
resent group instruction on preventive dentistry		✓			✓				✓		✓	
ssist in group instruction on preventive dentistry		✓				✓			✓		✓	

REQUENCY OF PERFORMANCE

. Never - Check this olumn if you do not perform this task in your resent duty position.

. Sometime - check this olumn if you perform this ask occasionally.

. Often - Check this olumn if you perform this ask on a regular basis.

WHEN FIRST PERFORMED ON JOB

1. Think back, when you first began working in the dental clinic, how long was it before you were called upon to perform these tasks? You may have applied abrasive to remove stains the first week, but it may have been several months before removing periodontal pack.

2. Leave this blank if you have never performed these tasks.

IS IT SUPERVISED

If the performance of the task is supervised indicate to what degree.

1. Never - If you are not supervised on this task, check this column.

2. Sometime - If you are not supervised closely, but "spot checked" from time to time, check this column.

3. Always - Check this column if you are closely supervised while performing this task.

4. Leave this column blank if you have never performed this task.

HOW CRITICAL

To what degree do you feel these tasks are necessary concerning proper job performance?

1. Must Know - Check this column if you feel this task is a necessity for effective job performance.

2. Nice to Know - Tasks which are normally performed, but are not essential for effective performance.

5. Instructions: Carefully complete the following questionnaire. Because of the relatively small sampling of personnel in your MOS, your answer will weigh heavily on the future design of the Dental Hygiene Course.

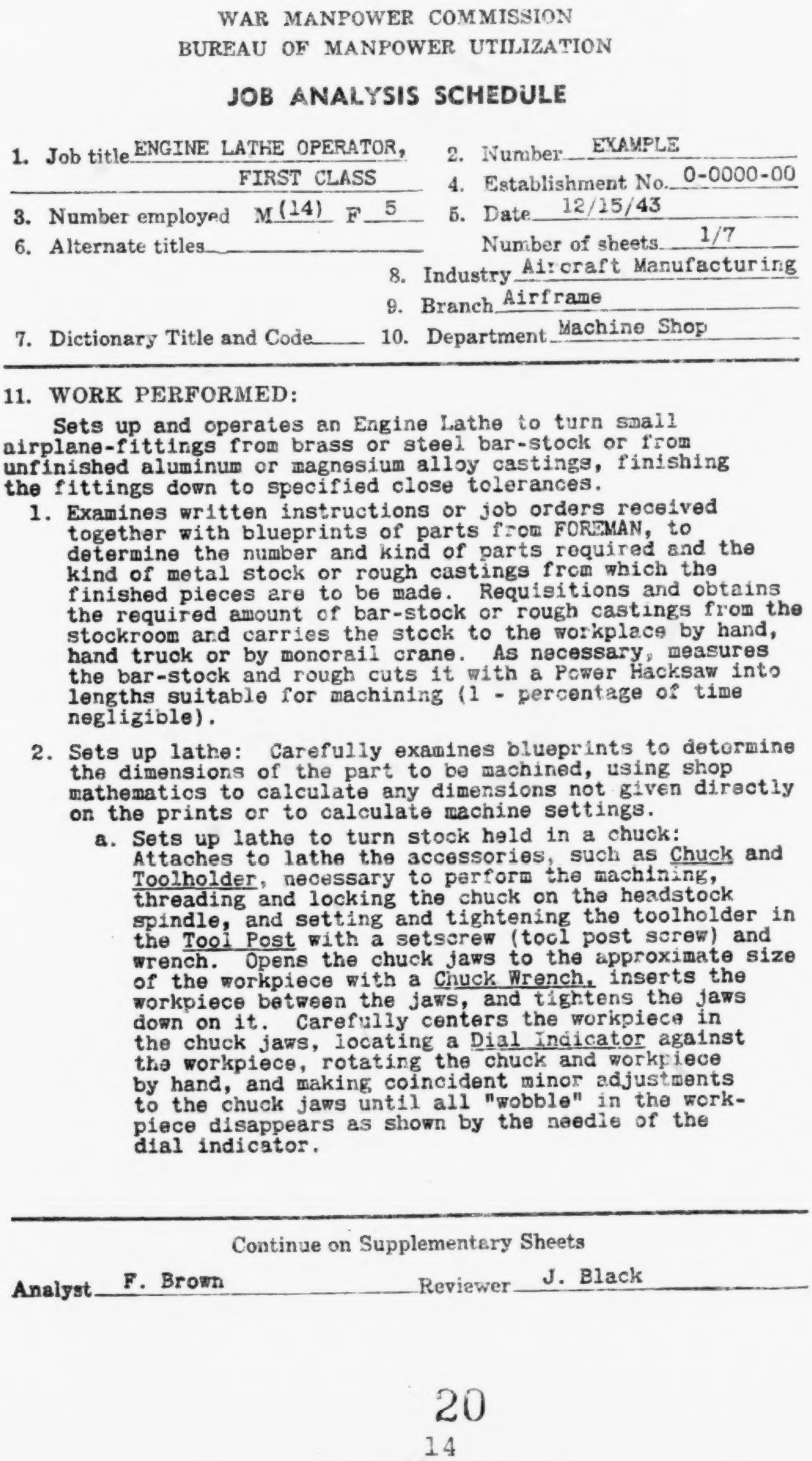
FIGURE 1 (continued)

QUESTIONNAIRE

TASKS	FREQUENCY OF PERFORMANCE			WHEN FIRST PERFORMED				IS IT SUPERVISED			HOW CRITICAL	
	Never	Some time	Often	0-3 Mo	3-6 Mo	6-12 Mo	Over 1 Yr	Never	Some Time	Always	Must Know	Nice to Know
/ / / / / / / / / PATIENT TREATMENT / / / / / / / / / /	/ / /	/ / /	/ / /	/ /	/ /	/ / /	/ /	/ / /	/ / /	/ / / /	/ / /	/ / / /
Properly position patient in chair												
Properly drape patient												
Record patient's medical history												
Examine patient's soft oral tissues visually without mouth mirror												
Examine patient's hard oral tissues visually without mouth mirror												
Examine patient's soft oral tissues visually with mouth mirror												
Examine patient's hard oral tissues visually with mouth mirror												
Examine patient's soft oral tissues by palpation												
Call to the attention of the dentist tissue deviations from normal												
Use periodontal probe during examination												
Use dental explorer during examination												
Use dental explorer during scaling												
Use air syringe during examination												
Use air syringe during scaling												
Use radiographs to determine location of local mechanical irritants (calculus, faulty restorations, etc.)												
Use radiographs for oral examination												
Expose radiographs												
Develop radiographs												
Mount radiographs												
Prepare records of exposure to ionizing radiation												
Use disclosing wafers before beginning prophylaxis												
Use disclosing wafers after completing prophylaxis												
Use disclosing solutions before beginning prophylaxis												
Remove tooth deposits (bacterial plaque, calculus, stains, etc.) with hand scalers												
Remove tooth deposits with ultrasonic equipment												

FIGURE 2

JOB ANALYSIS, ENGINE LATHE OPERATOR, FIRST CLASS



WAR MANPOWER COMMISSION
BUREAU OF MANPOWER UTILIZATION

JOB ANALYSIS SCHEDULE

1. Job title ENGINE LATHE OPERATOR, FIRST CLASS
2. Number EXAMPLE
3. Number employed M (14) F 5
4. Establishment No. 0-0000-00
5. Date 12/15/43
Number of sheets 1/7
6. Alternate titles
7. Dictionary Title and Code
8. Industry Aircraft Manufacturing
9. Branch Airframe
10. Department Machine Shop

11. WORK PERFORMED:

Sets up and operates an Engine Lathe to turn small airplane-fittings from brass or steel bar-stock or from unfinished aluminum or magnesium alloy castings, finishing the fittings down to specified close tolerances.

1. Examines written instructions or job orders received together with blueprints of parts from FOREMAN, to determine the number and kind of parts required and the kind of metal stock or rough castings from which the finished pieces are to be made. Requisitions and obtains the required amount of bar-stock or rough castings from the stockroom and carries the stock to the workplace by hand, hand truck or by monorail crane. As necessary, measures the bar-stock and rough cuts it with a Power Hacksaw into lengths suitable for machining (1 - percentage of time negligible).

2. Sets up lathe: Carefully examines blueprints to determine the dimensions of the part to be machined, using shop mathematics to calculate any dimensions not given directly on the prints or to calculate machine settings.
    a. Sets up lathe to turn stock held in a chuck: Attaches to lathe the accessories, such as Chuck and Toolholder, necessary to perform the machining, threading and locking the chuck on the headstock spindle, and setting and tightening the toolholder in the Tool Post with a setscrew (tool post screw) and wrench. Opens the chuck jaws to the approximate size of the workpiece with a Chuck Wrench, inserts the workpiece between the jaws, and tightens the jaws down on it. Carefully centers the workpiece in the chuck jaws, locating a Dial Indicator against the workpiece, rotating the chuck and workpiece by hand, and making coincident minor adjustments to the chuck jaws until all "wobble" in the workpiece disappears as shown by the needle of the dial indicator.

Continue on Supplementary Sheets

Analyst F. Brown Reviewer J. Black

FIGURE 2 (continued)

b. Sets up lathe to turn stock between centers: Threads and locks Faceplate on headstock spindle and inserts a spindle center into the hollow end of the spindle by hand. Clamps a Holding Dog about one end of the workpiece, holds the workpiece with one hand so the predrilled center hole of the workpiece is against the spindle center and the tail of the holding dog is engaged in a slot in the faceplate, and turns the tailstock handle until the tailstock center engages the other center hole with a pressure suitable for turning. Locks the tailstock in place by lever to hold the workpiece firmly in place. Similarly sets up stock off center to turn tapers on workpiece. (See Comments.)

Selects a Cutting Tool correctly shaped and sharpened for the type of metal and type of cut to be made and clamps it in the tool holder. Clamps the tool holder at a suitable cutting angle in the tool post on the compound rest, judging the angle of cut by eye. Referring to a handbook or on the basis of experience, selects the correct lathe speed according to the metal of the workpiece and the type of cut to be made. Sets the lathe speed control levers to the selected speed. (3 - total set-up time 15%.)

3. Operates Lathe to machine workpiece to specifications: Starts lathe by switch. Turns compound-rest-feed-screw handle to position the cutting tool against the workpiece and turns the cross-feed handle to make a trial cut. From the trial cut determines the number and depth of additional cuts necessary to complete the machining to specifications. Measures workpiece with scale, vernier calipers, or micrometer to determine a suitable depth for the initial cut. Sets the cutting tool to the selected depth and position of cut by turning the tool-post and cross-feed handwheels according to the graduated scales affixed to them. Engages the carriage feed by turning a lever and makes the initial cut along the length of the workpiece. Withdraws the cutting tool from the workpiece by reversing the cross-feed and carriage-feed handwheels. Measures the dimensions of the workpiece, calculates the depth of the next cut, and resets the cutting tool for the cut. Similarly measures, calculates for, and makes as many rough and finish facing, tapering, or boring cuts as necessary to turn the workpiece down to the specified dimensions of a finished part. (See Comments.)

   Replaces the cutting tool with a Cut-Off Tool, accurately measures the length of the part on the workpiece with a scale, and, turning the carriage and cross-feed handwheels, positions and feeds the cut-off tool to the workpiece until it is cut from the stock held in the chuck jaws. Loosens the chuck jaws by wrench and picks the scrap stock from the jaws by hand (similarly removes finished workpieces turned down from castings). Checks finished fittings for dimensional accuracy with precision measuring instruments and sets them aside for inspection. (2-70%)

4. Occasionally cuts threads to specifications: Selects a specially shaped cutting tool suitable for cutting the correct thread. Checks the cutting tool using a Thread Tool Gage and regrinds the tool to proper shape as required, using a Power Grinder. Positions and trues the workpiece in the chuck jaws and locks it securely in place. Sets the cutting tool in the tool post, feeds it to the workpiece, and adjusts its position according to the depth of the first thread cut to be made. Sets a lever to obtain a lead-screw feed of correct ratio to the

FIGURE 2 (continued)

spindle speed according to the number of threads specified per inch. Starts the lathe and engages feed to allow the threads to be cut automatically according to the speed of the lead thread. As necessary resets the cutting tool for greater thread depth and recuts the threads until they are checked as correct with a thread gage. (3- 5%)

5. Shapes cutting tools to correct contour, angle of rake, and clearance by holding and manipulating them against the surfaces of a power grinder. Checks the grinding of each tool with a scale to determine the correct shape for the kind of cut and kind of metal for which the tool is to be used. (3 - 5%)
6. Lubricates and cleans the lathe parts and accessories as required to keep bearing surfaces working smoothly and to insure that all lathe surfaces and parts for tools are free from metal chips, grit and grease.
7. Supervises, instructs and assigns work to ENGINE LATHE OPERATOR, THIRD CLASS (learners): Teaches learners practical methods of handling simple work assignments, including the use of the engine lathe, power grinder and Drill Press; how to set up machine and workpieces; check blueprints, figure dimensions, and measure workpieces using precision instruments; points out the most efficient approach in machining work to produce dimensionally accurate pieces and generally directs the activities of learners who work as helpers; assigns them such work as cutting stock with a power hacksaw, filing burrs, grinding simple tools, and cleaning machines and work area. (2 - 5%)

PERFORMANCE REQUIREMENTS

16. Responsibility

Is responsible for instructing and making work assignments to beginning workers, supervising their machine set-ups, and inspecting their work for quality. Responsible for the final machining of semifinished castings which are valued at as much as $50.00 each. Adherence to specified close tolerance is necessary in order to avoid spoiling castings.

17. Job Knowledge

Must have a thorough knowledge of the working properties of steel, aluminum, brass, and magnesium alloys in order to judge proper cutting speeds and the shape of cutting tools. Able to read, interpret, and use shop mathematics to make computations from blueprints of intricately shaped parts. Completely familiar with the set-up, operation, and maintenance of the engine lathe described, involving knowledge of methods of chucking regular and odd-shaped parts for machining operations, such as cutting, turning, facing, threading, tapering and boring. Ability to judge correct angles of rake and clearance and to shape cutting tools for the different metals described. Ability to calculate machine speeds, select proper gear ratios, and set up lathe to cut standard screw threads. Must know how to use precision measuring instruments, such as dial indicators, vernier calipers, micrometers, and the like.

18. Mental Application

Must be able to plan involved nonrepetitive lathe set-ups and operational sequences to machine intricately shaped parts; must plan and improvise machine set-ups to overcome limitations of the lathe in such operations as the cutting of short, nonstandard tapers by adjustment of the compound tool rest; drilling and reaming by fitting special tools in tailstock, and the handling of long work and facing operations by positioning of center rests. Must be able to judge the relative difficulty of lathe operations to select work assignments for learners.

FIGURE 2 (continued)

19. Dexterity and Accuracy
Considerable care and dexterity is necessary to manipulate precision measuring instruments into correct position and adjust them to correct tension to assure accurate readings (worker must have the "feel" of the instruments). Must exercise care in turning lathe-control handwheels to avoid inaccurate reading caused by gear backlash, and to assure work within an allowed tolerance of .001 of an inch.

COMMENTS

20. Equipment, Materials, and Supplies
Equipment:
Engine Lathe:—Dobbs and Hobson; Model X; 15 inch bed. Engine Lathe accessories and tools including chucks, faceplates, tool holders, cut-off tools, and cutting tools.
Chuck:—A four-jawed vice-like fixture for clamping work to the headstock spindle of a lathe. The jaws can be adjusted and locked by a T-like chuck wrench.
Cut-off tool (Cutting-off tool):—A square-nosed, blade-shaped, metal-turning tool used for cutting off finished work from stock in a plane perpendicular to the axis of rotation.
Cutting tool:—A metal-turning tool which is ground at one end to provide a required cutting point for making either rough or finish cuts on steel, brass, or other metal.
Faceplate:—A large disk-like fixture for holding work to the headstock spindle of a lathe. The work is held and rotated by a holding dog which fits about the work and in holder or slots in the faceplate.
Holding Dog:—A device used to turn bar-stock in a lathe when it is not possible to hold the stock in a chuck. The dog consists of a ring which slips over the workpiece and is clamped to it by a setscrew. Extruding from the ring is a lug (tail) which engages in a slot in the faceplate causing the dog and workpiece to turn with the faceplate.
Tool Holder:—A device, clamped in the tool post of a lathe, used for holding a cutting tool firmly in a definite position with respect to the work to be machined.
Micrometers, vernier calipers, dial indicators, thread tool gage and other precision measuring instruments.
Dial indicators:—An instrument which shows variations from trueness in a rotating workpiece. The indicator is simply a calibrated dial to which is attached a sensitive contact point. The responses of the point to unequal rotation of the workpiece are multiplied to the dial by levers and gears.
Thread tool gages:—A small flat steel gage for checking the shape of thread-cutting tools. The gage has V-shaped notches for checking the shape of the tool point for standard threads and shallow notches for checking the point width of tools for cutting flat-crest (Acme) threads.
Vernier calipers:—A beam type rule having jaws square with the beam. The movable jaw has a vernier-micrometer adjustment to read thousandths of an inch.
Open end and socket wrenches, chuck wrench, pliers, and other machinist's hand tools for setting up and adjusting the lathe.
Chuck wrench:—A short T-shaped socket wrench used to adjust and lock the jaws of a lathe chuck.
Materials:
Unfinished aluminum and magnesium alloy castings. Steel and brass bar-stock in round, hexagonal, or square cross section.

FIGURE 2 (continued)

Supplies:
Lathe lubricants such as oil and grease.

21. Definitions of Terms

Angle of rake:—The angle formed between the cutting edge of a tool and a line perpendicular to the axis of rotation of a workpiece at the point of cutting contact.
Boring:—A term used to designate the machining or cutting of internal cylindrical surfaces in a workpiece.
Compound rest:—That part of the lathe carriage assembly which carries the tool post; it has a feed screw for fine advancements of a tool into a workpiece and may be locked in any angular position in a horizontal plane.
Facing:—A term used to designate the machining of a true surface on a workpiece in a plane perpendicular to the axis of rotation of the workpiece.
Tapering:—A term used to designate machining which lessens the diameter of a workpiece at one end.
Tool post:—A device for clamping a tool holder (and tool) to the compound rest of a lathe. It generally consists of a short steel post, a base, and a tool post screw.

22. General Comments

Items 1 and 12. The job of ENGINE LATHE OPERATOR is divided on the basis of skill into three classes, designated FIRST CLASS, SECOND CLASS, and THIRD CLASS. The operator, THIRD CLASS is a learner who is promoted automatically to operator SECOND CLASS at the expiration of six-months' training time. The operator SECOND CLASS works on parts involving simple machine set-ups of a low enough range to be repetitive, maintains ordinary cutting tools such as cut-off or facing tools, works to liberal tolerances (.005) and on materials of low cost, such as castings, on which no previous expensive machining has been done. He uses the same precision measuring instruments as the operator FIRST CLASS. He is not promoted automatically to operator FIRST CLASS but will be considered for such a promotion after 12 months' experience.
Element 2b. This type of set-up and operation was not observed but was described to the analyst by the worker.
Element 3. Usually two cuts are required, one rough and one finish, for small cylindrical parts. The number of cuts required to finish irregularly shaped castings varies according to the number of surfaces to be machined and the kind of machining to be done, such as facing, tapering or boring.

continued, even though "wiping lead" itself has declined in importance.

Apart from "criticality," the test developer must consider such factors as the time required to perform a given task, the type of equipment required, the ability to present the task in a uniform (standard) manner, and the ability to evaluate an individual's performance with a high degree of objectivity. Considerations such as these impose realistic constraints on the tasks one selects to be parts of a performance test. Often compromises are in order. Instead of requiring performance of a complex task, one may decide to limit the test to one or two phases of the task, such as checking out an engine before starting it or making a critical adjustment in one element of a complex system.

In the job description for a power plant operator/mechanic (see Figure 3), some of the job elements that could be tested have been underlined. But the statement is too general to be of much use for test development purposes. The tasks need to be broken down into subtasks and should include descriptions of the equipment on which the tasks are performed. Thus, for the task "Performs organizational maintenance and repair of equipment, test-operates equipment, localizes malfunctions, and determines the extent of repair required," one would need to determine that the operator is expected to perform these tasks on a five-kilowatt portable generator. A given make and model can be specified to avoid any possible ambiguity. Now the test writer can design problems that pertain to this equipment.

Figure 4 defines what an operator/mechanic must do to troubleshoot a starting circuit on a five-kilowatt generator set. A comparable degree of specificity is needed for each of the other subtasks. In this way the generalities of the job description may be translated into the performance requirements that provide the basis for a meaningful assessment.

FIGURE 3

JOB DESCRIPTION - POWER PLANT OPERATOR/MECHANIC

Duties

Installs, operates, maintains, and repairs both standard and precise power portable generator sets and frequency converters equipped with electric motor, diesel, gasoline, or gas turbine engines and associated equipment. Calculates electrical power requirements, selects power generator or generators to be utilized, determines load cable sizes, and connects load cables to generator terminals. Starts required number of generators, synchronizes generators, and sets manual and automatic control devices to maintain power output. Installs cable racks to carry power cables from generator to transformers and control and distribution panels. Erects outside distribution lines for short distances. Observes equipment and panel instruments and make appropriate adjustments to insure proper balance of load, phase relationship, and effective functioning of equipment. Operates manual controls in case of failure of automatic control devices. Cuts out defective units and cuts in standby units. Performs organizational maintenance and repair of equipment. Test-operates equipment, localizes malfunctions, and determines extent of repair required. Replaces defective components of generators, gas turbine engines, diesel and gasoline engines, and control panels. Prepares operational and maintenance reports and keeps records pertinent to operation and maintenance of equipment.

Skills and Knowledges

Must know fundamentals of electricity and its application to portable power generating equipment. Must know fundamentals of gasoline and diesel engine operation. Must know safety and operating characteristics of circuit breakers, switches, and other protective and controlling devices. Must know precautions to be exercised when working with electrical equipment and emergency action required in case of injury to personnel. Must know organizational maintenance procedures applicable to portable generators and accessory equipment. Must be able to diagnose malfunction of electrical generator equipment, and gasoline and diesel engines. Must be able to use mechanic's and electrician's handtools and measuring and testing devices. Must be able to compute voltage, amperage, and resistance factors involving simple algebraic formulas. Must be able to install cable racks to carry power cables from generators to transformers and control and distribution panels. Must be able to erect outside distribution lines and cables.

Code 52B30. Must be qualified as Power Generation Specialist (52B20). Must know fundamentals of gas turbine engine operation. Must know organizational maintenance procedures applicable to precise power generators, frequency converters, and gas turbine driven generators. Must be able to use special tools and test equipment required to perform organizational maintenance of portable precise power generating equipment.

Physical Requirements

Requires capacity to perform physical activity requiring full use of upper and lower extremities. Requires eye-hand coordination and manual dexterity to grasp and manipulate tools, instruments, and components of electrical generating equipment. Requires auditory acuity to distinguish various pitches and tones of sound in order to detect malfunctions indicated by unusual operating noises. Requires color discrimination to distinguish color-coded circuits.

Mental Requirements

Requires reasoning ability to determine cause of defective functioning of equipment and repairs required. Requires mechanical aptitude to maintain and repair electrical and power equipment. Requires emotional stability to work around high voltage equipment.

FIGURE 4

PLAN OF PART OF A PERFORMANCE TEST

Subtask: Troubleshoot the starting circuit of a 5 kilowatt generator set.

a. Attempt to start engine electrically

b. Check battery voltage and specific gravity

c. Disconnect battery

d. Trace engine start circuit on schematic

e. Make continuity checks of start circuit with multimeter

f. Locate defect on equipment and schematic

Once a test plan has been developed outlining the tasks to be accomplished, details must be provided regarding such matters as equipment, materials, and procedures. The amount of detail may vary considerably depending on the subject matter involved. But the fundamental purpose remains: one must specify precisely what the examinee is to do and the conditions under which he is to do it. There should be no doubt in his mind as to what is expected of him and on what basis his performance will be evaluated. The stenographer who is given a work sample of dictation knows that she will be judged in terms of the speed and accuracy as well as the overall appearance of her work. To test a machinist's ability to use a lathe, it is necessary to provide him with specifications or blueprints of the object to be fabricated as well as the raw materials with which he will work. He also needs to know how much time he will have and what the acceptable tolerances are for the job.

The development of a performance test is an evolutionary process. Once a specific task element has been selected, it is a good idea to list the necessary equipment and to set down the necessary procedures for that element. Figure 5 singles out one item from the troubleshooting subtask given in Figure 4: "Attempt to start engine electrically" and lists the equipment that would be required and the steps one would perform in accomplishing this task.

This example of the procedure for performance test development, began in Figure 3 with the job description for the power plant operator/mechanic. It continued in Figure 4 to illustrate the more detailed plan for a test of part of the performance of the job. Figure 5 carries the process one step farther, by providing a detailed list of proper procedures for performing the job element of "attempt to start engine electrically." For a complete test, each of the elements in Figure 4 would be treated in the same way with the development of detailed procedures and an equipment list.

FIGURE 5

EQUIPMENT AND PROCEDURES LIST FOR PART OF A PERFORMANCE TEST

Equipment list:

- 5 kilowatt generator set
- load bank
- load cables
- multimeter
- hydrometer
- standard tool kit
- schematic-engine, plastic covered
- grease pencil

Procedures

a. Attempt to start engine electrically

1) Place fuel valve in tank position

2) Place oil pan baffle rod in proper position

3) Place air cleaner intake shutter in proper position

4) Place governor control in start position

5) Place remote/local switch in local position

6) Place emergency run/stop switch in normal position

7) Hold start switch in start position (no more than 15 second intervals)

The next steps, after proper procedures have been determined, are to draft the documents that will make it possible for the test to be administered by different people at different times in a standard and objective manner. Before proceding to those steps, however, let us digress briefly and consider some problems related to the evaluation and grading of performance, since these are crucial concerns in the developmental process. We will return to the power plant operator/mechanic illustration in Chapter V.

CHAPTER IV

GRADING THE PERFORMANCE TEST

Whatever the nature of a performance task, sooner or later the problem of evaluating performance must be faced. This is not always an easy matter, because where one places his emphasis can be a matter of critical importance. One can focus on the product, on the process, or on both.

In attempting to arrive at a decision regarding the question of evaluating performance, a Navy chief machinists mate who was working on a test for structural mechanics said, "I don't care if a man stands on his head while doing a job, as long as it's O.K. when he's finished." This man might be described as "product-oriented." He was concerned only with the precision attained in the final product and with its correct operation. While most evaluators would agree that "quality of the final product" is of great importance, they are likely to argue that some consideration should be given to the "process" by which the final product is obtained. They would evaluate the individual's care of the equipment he uses, his observance of safety rules, and his adherence to approved methods of work. They might also take into account the amount of material he wastes and the time he takes to do the job.

In practice the relative weights to be given to "process" factors and to the "end product" will depend on the objectives of a particular test and the nature of the task involved. Evaluating "process" is a time-consuming and expensive procedure. Great care must be exercised in developing rating forms and in training observers. At best, results may not be as dependable as one would like because of subjective factors beyond the evaluator's control. Questions naturally arise as to how much importance should be attached to "process" ratings. In the original planning for a structural mechanics test, equal weight had been given to "process observations" and to "final product ratings." The chief machinist mates objected. They pointed out that a man might seem to _do_ all the right things ("the process") and yet end up with an unusable _product_. They insisted that substantially greater weight be assigned to "product ratings" than to "process ratings."

In all likelihood this battle must be fought anew each time a performance test is developed, for it involves a value judgment that can be made only by those responsible for program design. There is justifiable concern, for example, that correct procedures and safety considerations--stressed in the instructional program--will be undermined if "process" is ignored by the evaluators. If evaluation is perceived as an integral part of instruction, then this viewpoint is certainly defensible. If, on the other hand, the purpose of evaluation is to predict subsequent on-the-job performance, the major consideration should be how much the "process" score contributes to the overall validity of the performance test. Unless higher validity can be demonstrated, it is questionable that the effort and expense involved in measuring it can be justified.

"Product evaluation" is easier to deal with than is "process evaluation." For one thing,the product is usually a tangible object, more durable than the fleeting actions which make up a process. Such a product may be judged without time pressure _after_ the testing has been completed. Process evaluation, on the other hand, must generally be done _while_ the testing is in progress.

In the case of a tangible product it is generally easier to obtain reliable judgments regarding quality than in the case of a process. If the product is one that has been made to precise specifications (such as those given in a blueprint), it is possible to check how closely the product conforms to the specifications. However, one should not overestimate the ability of judges to evaluate such a product adequately, even when precise specifications are available and the judges use fine measuring instruments to check for accuracy. In one of the few published reports of research on this topic, Stuit (1947) describes a situation in which four instructors were asked to assess the quality of 30 "samplers" prepared by students in a basic machinist course. Although the judges used appropriate instruments to make their evaluations, there were many discrepancies among the grades assigned to the same samplers. Judges' ratings intercorrelated from .11 to .55. Then a set of taper gauges and caliper gauges was devised with scales for five points of deviation on either side of the specifications. When these gauges were used in scoring the samplers, the ratings correlated .93 on one set of samplers and .96 on another (p.306). This suggests that every effort should be made to make product evaluation as objective as possible and that various kinds of jigs and gauges may be useful for this purpose.

In situations where quality must be judged subjectively, it is important to list those characteristics which differentiate the good from the poor product and to devise techniques for measuring or otherwise assessing these characteristics. It is sometimes possible to increase the reliability of judgments by developing a comparative scale. This may be done by having a group of highly competent judges place a number of "products" in rank order on the characteristic being rated. When a stable scale has been created (to provide benchmarks for differing degrees of goodness), it may then be used by less qualified judges to ascertain where along the scale a given product fits.

When the end "product" is actually a service--such as in the repair of an automobile or a television set--the judgment is generally in terms of utility. Does it work? How well? However, it is unlikely that one would be satisfied to know merely that an examinee made the repair. Part of the evaluation would hinge on how long the repair took and whether the solution was the most efficient one for the particular situation involved. Such questions inevitably take one over into the area of process, for one is now concerned with how the job was done, not merely with the end result.

As indicated earlier, how much importance to attach to process evaluation is a value judgment which depends in large measure on the purpose of the evaluation. In attempting to select a machinist who can meet extremely precise specifications, one might be less concerned with the procedures he uses or with the time he requires to do the job than with the end result. However, in selecting an instructor for a vocational program, one might attach considerable weight to "process" as well. In each instance the importance of evaluating process must be weighed against the effort and expense involved in obtaining information about it.

When information about process is deemed to be an essential part of evaluation, great care should be exercised in defining specifically what type of information is needed. Specifications for process evaluation should emerge from the job analysis. How important is speed? Accuracy? Use of approved methods? Care of tools and equipment? Adherence to safety standards? There is no point in burdening the observer with the assessment of attributes which are not of critical importance. By focusing only on the essential elements of "process," the chance of obtaining reliable judgments is increased. Requiring extraneous observations is almost certain to occur at the expense of overall accuracy.

After the process dimension has been defined adequately, a rating form should be devised. Such a form is essentially a check list covering each step of the process and providing criteria for making process judgments. Stuit reports that, in devising rating forms for performance in various Navy enlisted schools, "sheets which allowed considerable leeway in evaluating quality of performance were found, in general, to be unreliable because different instructors did not agree in grading trainee performance. For objective scoring the proctors' check sheets were made highly specific..." (p.300).

The problem of rater reliability to which Stuit refers has continued to be a major drawback in "process evaluation." Unless reasonably uniform rating standards are adhered to by all observers, it is impossible to disentangle the variance in scores attributable to differences in examinee performance from that attributable to differences in rater "performance." Training of observers deserves much greater attention than it has received in the past. Even if this were done, it is questionable how much uniformity could be achieved. The experience of the College Entrance Examination Board in training teachers to grade CEEB essays suggests that only small gains in reliability can be expected even when a substantial effort has been made to train the raters.

The advent of videotape recorders may offer a fruitful approach to the training of observers. After some training in the use of an observer's checklist, prospective observers could be shown a videotape recording of an examinee taking a test. After these observers had completed their ratings, discrepancies among raters could be discussed and any differences resolved. Then the group could be asked to rate a second set of videotape recordings. These observers who persisted in making divergent ratings might be exposed to further training or dropped from the roster of qualified observers.

In some situations where process evaluation is of great importance, it may be possible to record an entire test performance on videotape so that two or more observers could rate the individual after the performance had been completed. Where ratings differed, judges could re-examine the tape together, discuss the behavior in question, and resolve their differences; or a neutral judge could be called in to assist in reaching a decision.

This chapter has merely scratched the surface in exploring the problems of evaluating and grading performance. It does, however, provide a basis for proceeding to the concrete example of preparing a performance test for part of the job of power plant operator/mechanic as a vehicle illustrating the test development process. The chapter also gives background for considering the variety of testing and grading techniques that are shown in the following sections of the *Handbook*.

CHAPTER V

DOCUMENTS FOR A PERFORMANCE TEST

Once the test developer is satisfied with procedures, directions, equipment, and scoring methods for a performance test, he should formalize them by preparing three documents.

1. Instructions to the Test Administrator or Observer

   These instructions outline the procedures to be followed, list the equipment that is needed, point out especially hazardous aspects or emphasize safety precautions that are applicable, and tell the administrator how to set up the equipment for the exercise. This document also tells how the test is to be scored. The instructions should be sufficiently detailed so that an administrator who is competent in the area covered by the test will be able to set it up, run through the tasks himself, and then administer the test to students in a standardized way. Figure 6 is an example of a set of instructions to the observer. Additional examples of instructions to test administrators will be found in the Appendix.

2. Instructions to the Examinees

   In very simple situations, directions to the examinees may be given orally. For example, to test a musician's ability, he might be given a sheet of music and asked to play the piece. However, such informality opens the door to the introduction of elements that could create unstandardized testing conditions. An examiner might give more detailed instructions to one individual than to another or he might inadvertently omit something that was important from his instructions. To prevent such occurrences, it is

FIGURE 6

INSTRUCTIONS TO OBSERVERS FOR A PERFORMANCE TEST

THE START CIRCUIT OF A 5-KW GENERATOR SET (PART I)

1. The administrative details concerning this test have been prepared in three parts. This is Part I. Part III is the rating form to be completed by the observer during the student's performance. It includes a listing of all the items to be judged. Part II is instructions to students. Observers are not to assist the students during the Performance Evaluation. They are to keep close surveillance of the student's actions for evaluation purposes and also to prevent accidents or damage to the equipment. Observers will evaluate the student on performance of requirements shown below. If the student successfully completes a step of a requirement, he is to be awarded the total amount of points for that step. If he does not successfully complete a step, he is to be given a zero for that step.

   a. This test is to be administered indoors, under artificial light.

   b. Cables and load banks will be connected for 120 volts, single phase, 60 cycle operation prior to the start of the Performance Test.

   c. Wire #P29B18 going from #2 terminal of the S6 switch to terminal #2 of the ammeter will be removed and replaced by a false wire.

   d. The following equipment will be furnished the student at the site:

      (1) 5 KW generator
      (2) Multimeter
      (3) Hydrometer
      (4) Tool kit
      (5) Schematic
      (6) Load bank
      (7) Connecting cables
      (8) Grease pencil

FIGURE 6 (continued)

e. When the student completes each detail noted on the performance rating form, record his score in the appropriate column. He will be graded on the following:

   (1) Attempt to start engine electrically
   (2) Check battery voltage and specific gravity
   (3) Disconnect battery
   (4) Trace engine start circuit on schematic diagram using grease pencil. The student will take each part of circuitry in sequence: (a) energize the K4 coil,(b) energize the K1 coil, (c) energize the K4 coil and (d) energize the start motor.
   (5) Make continuity checks of the start circuit with a multimeter
   (6) Point out the defect to the instructor on both the equipment and schematic

f. The maximum time allowed for the test is 30 minutes.

recommended that instructions be written ones and that they either be read to the examinee or be given to him so that he may study them beforehand. The instructions should state the purpose of the test; the time limits, if there are any; the equipment to be provided; the requirements that the examinee is expected to satisfy; special safety precautions; and information about how the test will be graded. In certain situations, some of these items may not be needed, but the person preparing the directions should make a considered judgment in each instance before omitting the information.

A major benefit of having written instructions is that each examinee receives exactly the same information about what he is expected to do. This makes for a more highly standardized testing situation. It also promotes greater confidence in the examinee since he knows that he can refer to his instructions if he becomes confused or forgets what he is supposed to do. He can check the equipment to make sure it is all there. He will be aware of what factors will be considered when the test is scored. Furthermore, there is no chance that the examinee may claim, later on, that the observer neglected to tell him something that was important to the successful completion of the task.

A word of caution is in order. Care should be exercised in developing the instructions to avoid revealing unintended clues as to the proper procedure. There should be no references in the instructions that suggest what the examinee should have done earlier or what results he should have obtained from certain procedures. An alert examinee may take advantage of such unintended clues and this may give him an unfair advantage over other examinees. Some of the differences in performance might then be attributable to "test-wiseness" or reading ability rather to the ability to perform a given task. Figure 7 is an example of a set of instructions to students.

3. Rating and Scoring Form

A rating form should be developed for each task. This is a highly individualized form which specifies the checkpoints on which the individual is to be evaluated. The determination of these checkpoints is, of course, vital. There should be as many as necessary to insure comprehensive coverage and provide reliability. Too few will probably indicate that some elements have been glossed over. On the other hand, too many may suggest "nitpicking" and a failure to differentiate between things that are critical and things that are trivial. The use of too many checkpoints may impose an impossible burden on the rater because he may have to watch for too many things at one time and he may miss important factors while he tries to grade performance on minor matters. For this reason, it is urged that in developing the rating form the test developer be selective and critical. He should pick items that are significant to job success. They must be of such a nature that they may be observed and judged with a high degree of objectivity. If experience shows that nearly everyone performs certain steps correctly, it may be advisable to omit that step as a checkpoint since it will not help to

FIGURE 7

INSTRUCTIONS TO STUDENTS FOR A PERFORMANCE TEST THE START CIRCUIT OF A 5 KW GENERATOR SET (PART II)

1. The purpose of the test is to provide you with an opportunity to demonstrate your ability in troubleshooting the start circuit of the 5 KW generator. Using the prescribed procedure you have been taught, you are to find any incomplete circuitry.

2. You will be allowed 30 minutes in which to complete the test. A satisfactory grade cannot be achieved unless the correct procedure is followed.

3. During a field exercise you are required to furnish power for lighting the area. The output power is 120 volts, single phase, 60 cycle alternating current. You have already performed the required Preventive Maintenance Services and you found no deficiencies.

4. The following equipment will be provided:

5 KW generator
Load bank
Load cables
Multimeter
Hydrometer
Tool kit
Schematic
Grease pencil

5. Requirements:

a. Attempt to start engine electrically (10 points)
b. Check battery voltage with multimeter and specific gravity with hydrometer and orally report to instructor (16 points)
c. Disconnect battery (5 points)
d. Trace the engine start circuit on the schematic diagram using a grease pencil, starting at (-) side of battery (22 points)

FIGURE 7 (continued)

e. Make a complete continuity check of the first part of the start circuit to make sure that K4 coil can become energized, with a multimeter (47 points)

f. Point out the defect to the instructor on both the equipment and schematic (20 points)

6. On completion of troubleshooting the circuit, move to the next station.

differentiate among the examinees. On the other hand, if a step is important from a safety standpoint, it should be included even if nearly everyone does it correctly. For example, if safety glasses must be worn while performing an operation, it would be advisable to include a checkpoint such as the following:

"Student wearing safety glasses? Yes___ No___
Do not allow student to proceed
with test until he puts on glasses."

At certain points the observer may have to check more than one item. If a voltmeter is used, it may be appropriate to check that it is properly connected to the unit and that the examinee has read the meter correctly. However, in many situations it may be desirable to have the examinee record dial settings and meter readings on a separate form that is specifically keyed to his instructions.

As noted in Chapter IV, the effectiveness of the measurement process will be reduced substantially if the observer must make judgments about quality along some sort of continuum. Experience has shown that rating scales do not work too well in performance test situations. It is preferable to design the rating at each checkpoint on an all-or-nothing basis. The examinee did or did not do what he was supposed to do. An example of this type of scoring form is shown in Figure 8.

After the various documents for a performance test have been developed, the whole package should be field tested. Tryout subjects should be proficient in the field covered by the test. They may be other instructors or practitioners of the trade. Advanced

FIGURE 8

OBSERVER'S RATING FORM FOR A PERFORMANCE TEST

THE START CIRCUIT OF A 5-KW GENERATOR SET (PART III)

Student______________Time Started________Time Completed________

Possible Score 120 Critical Score 84 Student Score_________

	Score if Task Properly Accomplished	Student Score
1. ATTEMPT TO START ENGINE ELECTRICALLY a. Place fuel valve in tank position	1	
b. Place oil pan baffle rod in proper position	1	
c. Place air cleaner intake shutter in proper position	1	
d. Place governor control in start position	2	
e. Place remote/local switch in local position	1	
f. Place emergency run/stop switch in normal position	1	
g. Hold start switch in start position (no more than 15 second intervals)	3	
TOTALS	10	

44

FIGURE 8 (continued)

	Score if Task Properly Accomplished	Student Score
2. CHECK BATTERY VOLTAGE AND SPECIFIC GRAVITY		
a. Place leads in proper jacks on multimeter	3	
b. Place function switch in proper position	3	
c. Check battery voltage and orally report to the instructor	5	
d. Check battery specific gravity and orally report to the instructor	5	
TOTALS	16	
3. DISCONNECT BATTERY (Negative Ground)	5	
TOTALS	5	
4. TRACE ENGINE START CIRCUIT ON SCHEMATIC		
a. Ground to S4 switch	1	
b. Through the S4 switch with switch in start position	1	
c. From S4 switch to the S5 switch	1	
d. Through the S5 switch	1	
e. From S5 to K4 coil	1	
f. Through the K4 coil	1	
g. From K4 coil to closed K2 contacts	1	
h. Through K2 closed contacts	1	
i. From K2 closed contacts to S6 switch	1	
j. Through S6 switch	1	
k. From S6 switch to the ammeter	1	

FIGURE 8 (continued)

	Score if Task Properly Accomplished	Student Score
l. Through the ammeter	1	
m. From ammeter to (+) side of the battery	1	
n. From S5 switch through K1 coil	1	
o. From K1 coil through closed K3 contacts	1	
p. From K3 contacts to ammeter	1	
q. From ground through K coil	1	
r. From K coil through closed K4 contacts	1	
s. From closed K4 contacts to the ammeter	1	
t. From ground through start motor	1	
u. From start motor through K contacts	1	
v. From K contacts to battery	1	
TOTALS	22	
5. MAKE CONTINUITY CHECKS OF START CIRCUIT WITH MULTIMETER		
a. Set the function switch, range switch, and zero the multimeter	4	
b. Check from ground to S4 switch at point 2	4	
c. Check continuity of S4 switch in the start position	6	
d. Check continuity of wire from S4 to S5 switch	4	
e. Check continuity of S5 switch	4	

FIGURE 8 (continued)

	Score if Task Properly Accomplished	Student Score
f. Check continuity of wire from S5 switch to terminal 1 of relay panel A	4	
g. Check continuity of K4 coil and K2 normally closed contacts from terminal 1 to terminal 3 on relay Panel A	5	
h. Check continuity of wire from K2 contacts to S6 switch	4	
i. Check continuity of S6 switch from terminal 4 to terminal 2	4	
j. Check continuity from terminal 2 of S6 switch to ammeter	4	
k. Check continuity from ammeter to terminal A of P1 cannon plug	4	
TOTALS	47	
6. POINT OUT THE DEFECT TO THE INSTRUCTOR ON BOTH THE EQUIPMENT AND THE SCHEMATIC		
a. Schematic	10	
b. Equipment	10	
TOTALS	20	
GRAND TOTALS	120	

students in the subject may also be used. It is important that the tryout subjects go through all the steps so that the observer may assure himself not only that the directions are clear and unambiguous but also that he is able to make the judgment called for at each checkpoint on the rating form. The tryout should debug the test and reveal any inconsistencies, errors, or even impossibilities. It should verify that all of the tasks are performable; that inserted malfunctions operate and give the indications intended; that adequate tools, instruments, and materials have been specified; and that the time limits are reasonable.

CHAPTER VI

VARIATIONS ON A THEME

The typical work-sample performance test has been discussed in some detail because it is the approach that has been used most frequently in the past and that is most likely to be used in the future. In this section several other approaches to performance testing, ranging from paper-and-pencil performance measures to simulation, will be considered. The purpose of doing this is to point out that it is advisable to consider alternatives before proceeding to develop work-sample tests. While these alternatives may have limitations which preclude their use as the sole basis for making judgments about an individual's ability to perform on a given job, they often have the advantage of economy and efficiency. For these reasons they should be considered as supplements to--if not replacements for--the work-sample type of test.

Paper-and-Pencil Performance Tests

The fact that a test is given in a paper-and-pencil format does not necessarily mean that it cannot approximate a work sample. On the National Architectural Registration Board Examination, the candidate is given a topographical map of a building lot and is instructed to develop a site plan for a specific structure such as a school or a church. On licensing examinations for plumbers, the candidate is frequently required to prepare a schematic showing how he would lay out water and sewer lines in a multi-story building. Figure 9 calls for an architectural draftsman to show where he would locate electrical outlets and switches in one room of a private residence. The task is one that lends itself very well to the paper-and-pencil format since it is one that is characteristically done in this way.

Figure 10 illustrates another electrical problem--this one designed for electrical maintenance technicians. The examinee is required to analyze a circuit diagram and to modify or complete the

FIGURE 9

A PAPER-AND-PENCIL PERFORMANCE TEST ITEM

The diagram below shows the floor plan of a master suite in a private residence. Directly on the diagram, locate the electric outlets and switches that are necessary and desirable for the entrance hall, bathroom, and bedroom.

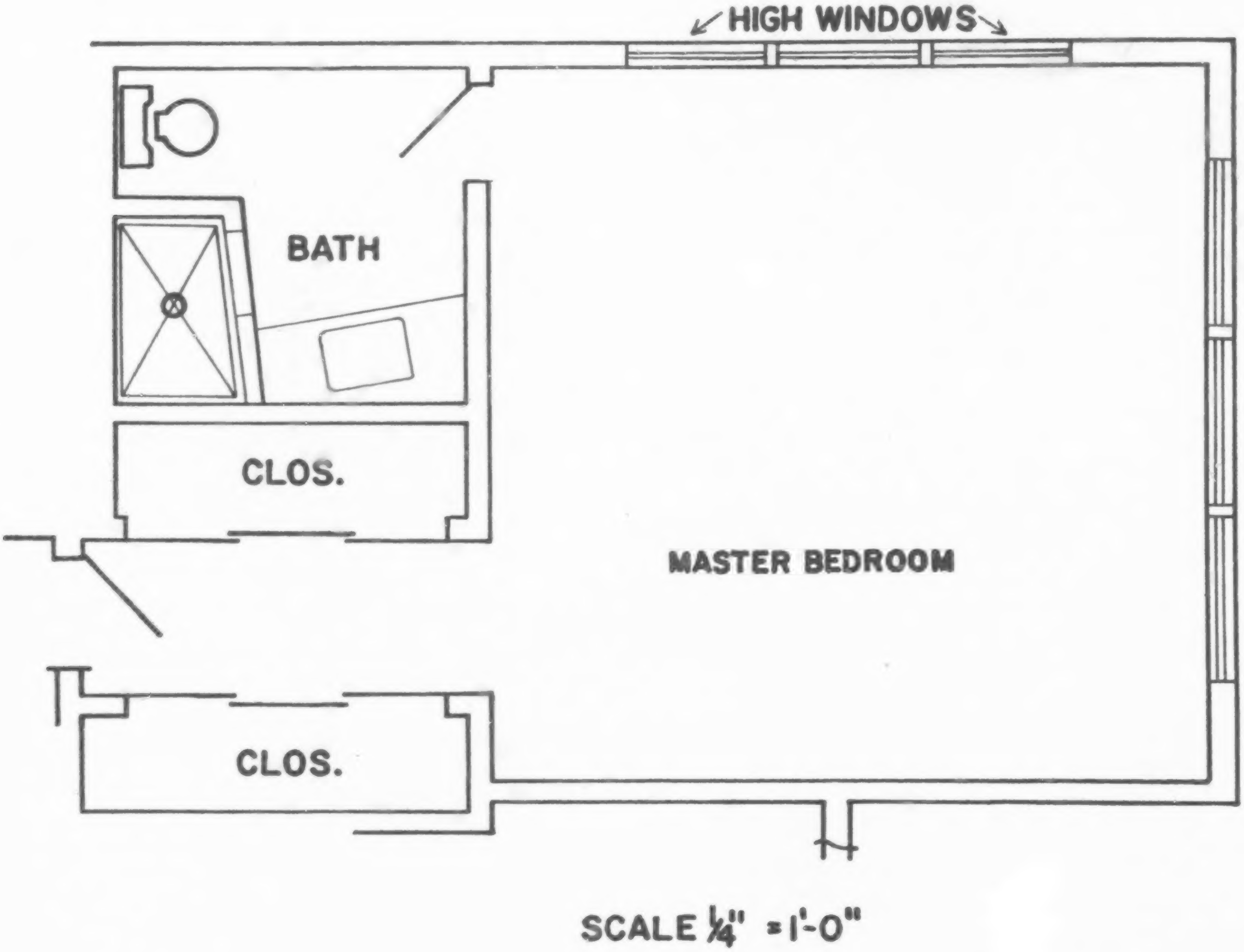
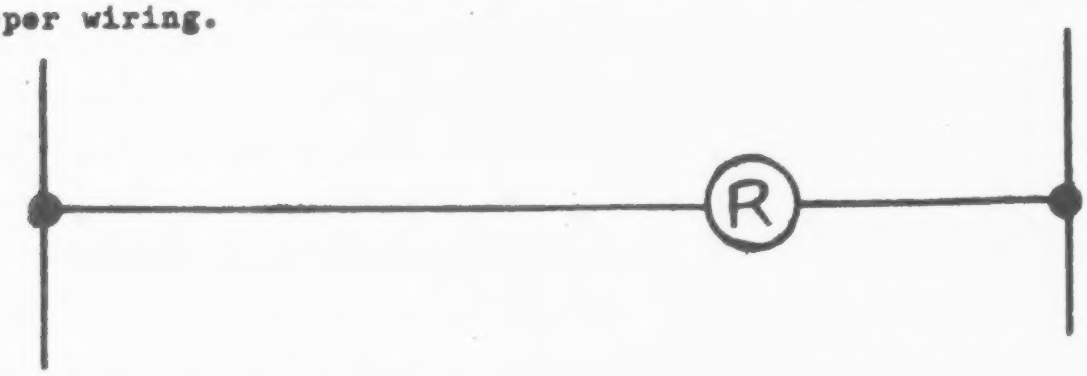

HIGH WINDOWS
BATH
CLOS.
MASTER BEDROOM
CLOS.
SCALE ¼" = 1'-0"

FIGURE 10

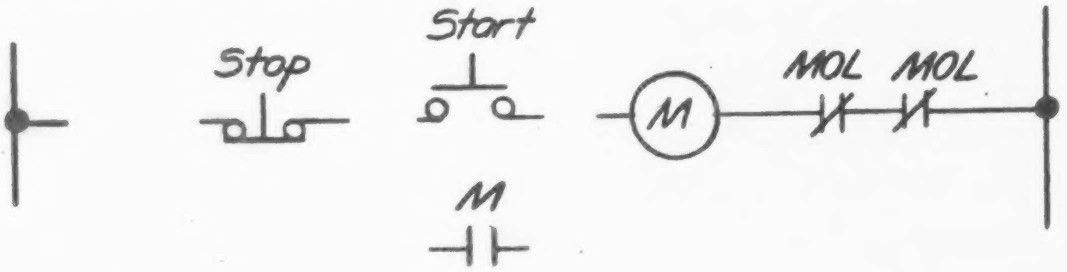
ANOTHER PAPER-AND-PENCIL PERFORMANCE TEST ITEM

Given the following RELAY CIRCUIT, complete problems 51 through 54 according to the conditions specified. Draw lines to indicate proper wiring.

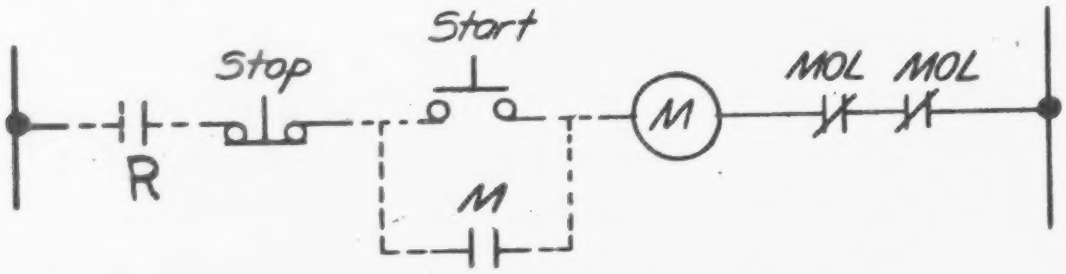


* * *

SAMPLE PROBLEM based on given Relay Circuit -
Referring to the given Relay Circuit, connect an R contact to allow the motor to be started and stopped normally when the relay is energized but prevents starting when the relay is de-energized. Motor is to stop if relay is de-energized while running.



SAMPLE SOLUTION. Note: Lines drawn to indicate proper wiring.



Study the above Sample Problem and the Sample Solution. Now, continuing to use the given relay circuit, complete the wiring diagrams in the same way for problems 51 through 54.

diagram so that the circuit will work in a specified way. This item type can present new and unusual problems to examinees and require them to apply their understanding of theory and good practice to the formulation of acceptable solutions.

A true work-sample test would appear ideal for bookkeepers, yet there is a danger here, involving the use of actual journals and ledgers, that should be recognized. Long, multi-stage problems often do not provide the examinee with enough feedback regarding the correctness of his earlier decisions and computations. Thus a minor arithmetic error in an early step would make many, if not all, subsequent steps incorrect. It is not practical for the examiner to try to adjust the examinee's answer to compensate for an error. However, full coverage of the range of bookkeeping skills can usually be tested by using a larger number of short problems in which the answer to any one problem is not dependent on the answer to an earlier one. Figure 11 shows part of a bookkeeping test in which the examinees are given a trial balance and information for making adjustments and are required to complete the adjustment columns of the work sheet. A problem in the preparation of a profit and loss statement is shown in Figure 12. The two problems given in Figures 11 and 12 illustrate the separation of a larger problem into two shorter segments. All examinees start the profit and loss statement problem with the same given information, and any errors they may have made in doing the work sheet problem do not follow them into the profit and loss problem.

Paper-and-pencil performance tests may also be used in technical fields such as automobile mechanics or heating and air conditioning. For example, an examinee may be given a set of problems requiring him to order the parts needed to make repairs on a given make and model of a car; or he might be required to select the equipment that would meet certain heating or cooling specifications and conform to space limitations indicated on an accompanying blueprint. Such tasks are highly realistic and job-oriented. The fact that the response is in a paper-and-pencil format in no way diminishes the validity of the performance.

FIGURE 11

PART OF A BOOKKEEPING TEST

BOOKKEEPING EXAMINATION--FIRST SEMESTER

The attached work sheet with the trial balance written in is the work sheet of the Hanson Grocery at the end of the monthly fiscal period.

Instructions:

On the 8-column work sheet which is given to you with the trial balance written in:

a. Write the proper heading.

b. Be sure to write in the column headings for each pair of columns.

c. Using the information listed below for the inventories, make the necessary adjustments in the Adjustments column.

d. Extend the proper amounts into the balance sheet columns.

e. Extend the proper amounts into the income statement columns.

f. Find the Net Income or Net Loss and place this amount in the proper columns.

g. Total all columns; be sure that the debits and credits of each pair of columns equal. Double rule the work sheet.

The inventories on December 31, 19--

Merchandise Inventory	$4000
Insurance (Unexpired)	192
Supplies	130

(The insurance policy was taken September 1, 1962, for 3 years--$216.)

FIGURE 11 (continued)

	Trial Balance			
	Debit		Credit	
Cash	1248	00		
Accounts Receivable	3600	00		
Mdse. Inventory	5000	00		
Supplies	230	00		
Prepaid Insurance	198	00		
Accounts Payable			2225	00
Joe Hanson, Cap.			6000	00
Joe Hanson, Drawing	300	00		
Inc. + Exp. Summary				
Sales			4313	00
Purchases	1650	00		
Delivery Expense	35	00		
Insurance Expense				
Misc. Expense	52	00		
Rent Expense	125	00		
Salary Expense	100	00		
Supplies Expense				
	12538 12538	00 00	12538 12538	00 00

FIGURE 12

ANOTHER PART OF A BOOKKEEPING TEST

Directions: Prepare a Profit and Loss Statement from the work sheet shown below. Possible score--20 points.

NASH PAINTING SERVICE

Work Sheet for Quarter Ended March 31, 19--

Account Title	Acct. No.	Trial Balance		Profit & Loss		Bal. Sheet	
		Dr.	Cr.	Expense	Income	Assets	L&P
Cash	1	2,215				2,215	
Painting Equipment	2	545				545	
(Acct. Rec.) Davis Mills	3	260				260	
(Acct. Pay.) Pittsburgh Paint Co.	22		225				225
Walter Nash, Capital	31		1,950				1,950
Service Sales	41		1,200		1,200		
Rent Expense	54	300		300			
Advertising Expense	57	55		55			
		3,375	3,375	355	1,200	3,020	2,175
Net Profit				845			845
				1,200	1,200	3,020	3,020

Solution: Nash Painting Service

Profit and Loss Statement

For Quarter Ended March 31, 19--

Income		
Service Sales		1,200
Expenses		
Rent Expense	300	
Advertising Expense	55	
Total Expenses		355
Net Profit		845

Checking on the ability of an individual to read various types of measuring instruments may also be accomplished through the paper-and-pencil format. This is illustrated in Figure 13. While this approach has the advantage of efficiency and is probably valid insofar as the actual reading of the scales is concerned, it does not include the psychomotor processes involved in placing the measuring instrument at the appropriate place and adjusting it so as to provide an accurate reading. Thus, while the paper and pencil test might reveal whether an examinee could read instruments accurately, it would not provide any assurance that he could actually make proper measurements in a work setting. Like the "paper" welders referred to earlier, there are probably "paper" scale readers who would not know how to make an actual inside measurement on a piece of tubing. The only way to verify that they do possess the necessary manipulative skills is to provide an appropriate work sample. This need not be an exhaustive sample but could concentrate on a number of critical facets. One would probably be safe in assuming that an examinee who could make appropriate measurements in these situations would be able to handle any less complex situation that might arise.

Identification Tests

One of the most useful nonperformance "performance" tests is the identification test. It may involve the use of actual objects or it may rely on photographs. In either case, there may be great variation in the degree to which the identification task approaches the reality of a job-sample measure.

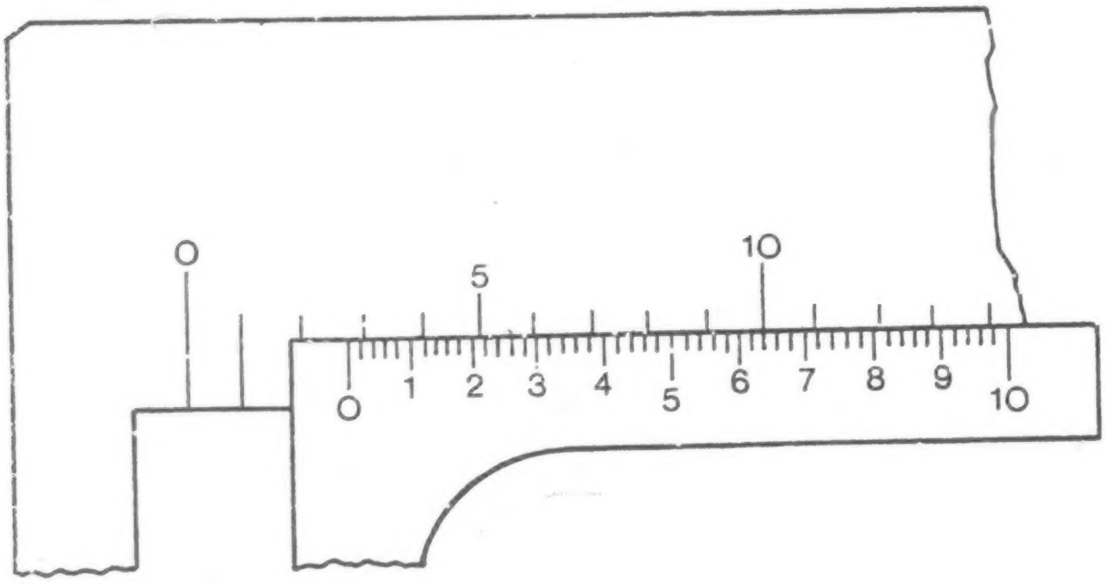
For the medical laboratory technician, it may be important that he be able to identify various types of protozoa quickly and accurately. In one training course the instructor placed prepared slides on fifty microscopes around the perimeter of the room, each one numbered from 1 to 50. Each student had a sheet with 50 numbered spaces on which he was to record his identification of the specimens. Thirty seconds were allowed at each microscope with

FIGURE 13

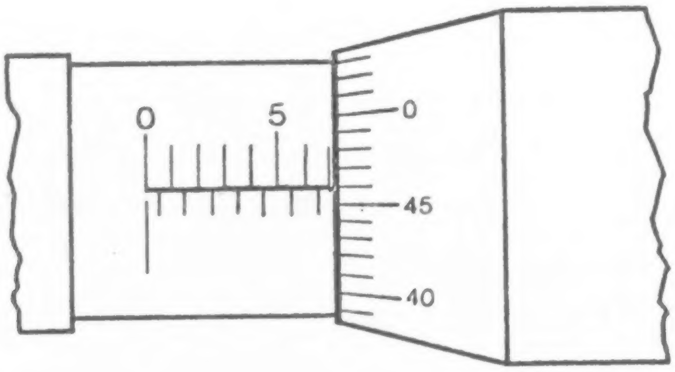
PERFORMANCE TEST ITEMS ON MEASURING INSTRUMENTS

Look at the vernier scale below.

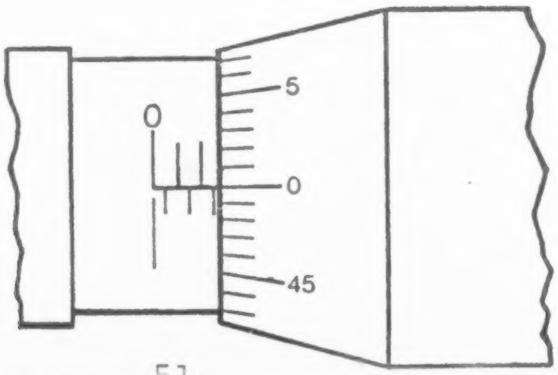
What is the reading? ________


0
5
10
0
1
2
3
4
5
6
7
8
9
10

What is the reading below? ________



. What is the reading below? ________



students moving from one microscope to the next on signal. Although this test lacked many of the elements found in an actual laboratory bench job (such as having to prepare the slides), it did provide the instructor with information about the ability of his students to make accurate identifications under test conditions. The same task might have been accomplished by projecting slides or using photographs. It would seem, however, that presenting the mounted specimens on a microscope stage came closer to duplicating the work setting than either of the other approaches would have done.

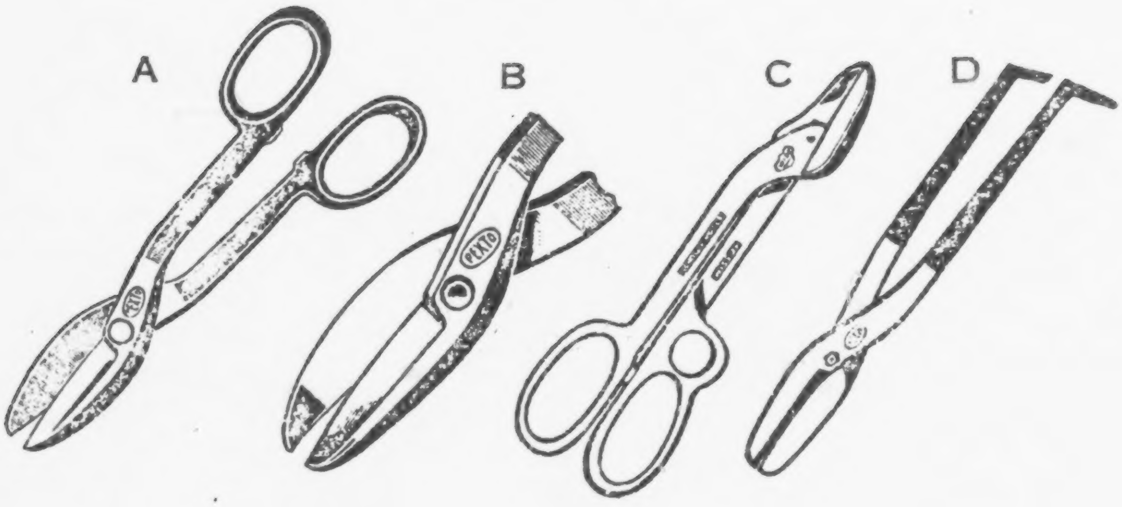
Identification tests are frequently used in skilled trades, such as plumbing, to determine whether an individual has a broad range of knowledge about various types of tools and fittings. It is not too difficult to use actual objects (as in the valve identification test described below), although photographs are sometimes used, as in Figure 14. The actual identification may take the form of an open-ended question, a multiple-choice question, or the selection of a key letter or number from a long list of possible answers.

Figure 15 illustrates the actual materials used in conducting an identification test dealing with valves. The material includes a planning sheet, a directions sheet, and a sample of a sheet used in connection with the display of the valve. The examinee is required to select the name of the part from a list of alternatives shown and to specify the function performed by that part, selecting the best answer from among five shown. He lists the number for each part and function on the answer sheet, which is also shown.

Still another variation on the format just described has been used in an identification test for automobile mechanics. The test consists of fifty small automobile parts or sections of large parts, most of which are damaged or defective. The examinee is required 1) to identify each part, 2) to tell what is wrong with it, and 3) to explain what caused the damage. Figure 16 shows a

FIGURE 14

AN IDENTIFICATION ITEM



Which of the tools shown above is the best one to use to cut curved or irregular lines in sheet metal?

FIGURE 15

AN IDENTIFICATION TEST

VALVE IDENTIFICATION TEST
PLANNING SHEET

I. **Purpose of the test.** This test is designed primarily to measure the trainee's acquaintance with the various kinds of valves that he disassembles and assembles by testing the trainee's knowledge of
(a) the names of the various parts, and (b) how these parts function.
This test uses actual valve parts instead of verbal descriptions or pictures.

II. **Items (Valve parts to be identified).** This test consists of 29 valve parts selected from the following types of valves: gate, globe, check, bottom blowdown, pressure relief, pressure regulating, boiler feed stop and check, safety, steam trap, boiler feedwater regulator, and main steam stop valve. (An odd rather than an even number of items is chosen for the test in order to permit a smooth flow of students from station to station.)

III. **Time required per student.** A trial run on the identification of the 29 selected parts of valves shows that each identification and determination of function requires no longer than 50 seconds. Allowing time for giving directions and collection of papers, a period of a half-hour is needed to administer this test to 29 students. (If the number of students exceeds slightly the number of items included in the test, dummy stations with blank item cards are included in the circuit to accommodate the few extra men. The total testing time will be slightly increased.)

V. **Assistance needed.**

a. Twenty-nine selected valve parts.

b. Twenty-nine cards (one for each valve part) on which has been typed the test item consisting of a list of five names of parts and a list of five functions of parts. Each part and test item card are known as a station. Each card is numbered to indicate the item and station.

Tables arranged in a hollow rectangle. The arrangement is illustrated in Figure 4.

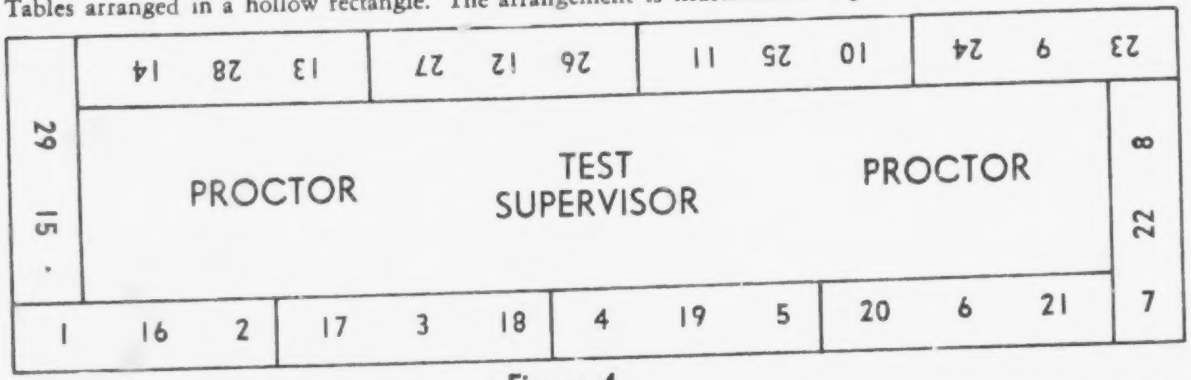


Figure 4

This diagram indicates how the cards (test items) are arranged. The numbers of the two halves of the series are laid out alternately. By moving *two* stations to the right each man answers all items in correct numerical order. By this arrangement, trainees on either side of a man are not working on adjacent parts of the test. This layout reduces the likelihood of mutual assistance, and it also makes it easier for proctors to detect copying. A man must make two complete circuits of the table to complete the test.

d. Separate answer sheets. Answer sheets are needed for each man. Each item has two blanks for recording answers; one blank for the name of the part, the second blank for the function. The answer sheets are laid out at the stations before beginning the test. At each individual station the item number corresponding to the station is circled in red pencil on the answer sheet to indicate at what part of the test the man is to begin.

e. A watch with a second hand or a stop watch.

f. A whistle. The blowing of the whistle at 50-second intervals is the "change stations" signal.

g. Timekeeper's card with an arrangement of numbers as shown below.

TIMEKEEPER'S CARD

60	60	60	60	60
50	50	50	50	50
40	40	40	40	40
30	30	30	30	30
20	20	20	20	20
10	10	10	10	10

This card will help the supervisor keep account of the 50-second intervals.

V. **Assistance needed.** Two proctors. Test supervisor will act as timekeeper.

FIGURE 15 (continued)

VALVE IDENTIFICATION TEST

DIRECTIONS SHEET

I. Directions for administration of the test.

1. Before the test begins make sure that all preliminary arrangements have been attended to by checking to see that each item card matches the valve part, that stations are properly numbered, that the answer sheet at each station is properly marked with a red circle around the item number that corresponds to the station, and that a scoring key has been prepared.
2. Place the trainees around the tables so that *one and only one* man is at a station and that there are no vacant stations between the men. In case the number of men being tested is less than the number of items in the test, remove the extra answer sheets.
3. See that each man has a pencil. Have a few extra in reserve in case trainees break their pencil points.
4. Read "DIRECTIONS TO STUDENTS" aloud. Answer questions. Then say "READY, BEGIN."
5. At the end of each 50-second interval blow the whistle as the "change station" signal. Use the timekeeper's card to indicate the elapse of 50 seconds by crossing out the appropriate figure in the vertical columns each time the whistle is blown. Give the directions for starting when the second hand of your watch is on 60. Cross out the "60" at the top of the first column. The figure 50 which appears below tells you to blow the whistle when the second hand of the watch reaches 50. Continue in this manner until the test is completed.
6. During the progress of the test, make sure that the proctors continue to check the work of the students, seeing that the answers are recorded in the proper places on the answer sheet.
7. When the test is completed, collect the answer sheets and send the students to their next assignment.

II. Directions to students (To be read aloud by the test supervisor).

1. "This is a test designed to measure your ability to *identify parts of various types of valves and the function or use of each part.*
2. "Write your name, section number, and the date in the spaces on the answer sheet.
3. "Notice the large number at the top of the card in front of you. This tells you the number of the station at which you are now standing. Find this same number on your answer sheet. It has been circled with a red pencil. This circled number shows you where to start marking your answers.
4. "Above the card you will find a part from a valve. You may pick up the part and examine it if you wish. On the left side of the card are five names of parts; one of these is the name of the part before you. Select the correct name of the part and notice the number 1, 2, 3, 4, or 5, in front of it. This is the number you are to write in the first blank space beside the red circle on your answer sheet. If you are not sure of the correct name, make the best guess you can. On the right hand side of the card are five statements of part functions. One of these statements describes a function or a purpose of the valve part. Select the correct function and notice the number in front of it. This is the number you are to write in the second blank space to the right of the item number. If you are not sure of the answer, make the best guess you can. If you wish to change an answer, erase and write in your new answer.
5. "As you change stations leave the card and part where you found them. When the whistle blows, take your answer sheet with you and move TWO stations to your right, to the station with the next higher number. After you reach the highest number (29 for this test), your next station will be 1.
6. "After you finish at each station, put your answer sheet face down on the table and stand by that station until the whistle blows.
7. "Are there any questions?" (Allow time to answer any legitimate questions.)
8. "READY, BEGIN." (Give this signal when the second hand of your watch is on "60".)

III. Directions for scoring.

Scoring of the identification test may be accomplished in any one of three ways:

1. The usual method of scoring is to count the total number of correct responses given by the trainee. The number of right answers for the identification of "Name" is added to the number of correct answers given for the "Function" and this total is the score on the test. It is obvious that the total possible score is a number which is twice the number of items on the test.
2. A second method is to score each item on an "all or none" basis, that is a trainee must answer correctly both the "Name" and the "Function" on each item in order to receive credit for the item. Any item for which the right name but the wrong function is given or vice versa is counted as incorrect. The total possible score is the same as the number of items on the test.
3. The third method of scoring is a combination of the previous two. In this case one point is credited for each "Name" correctly identified, one point for each "Function" correctly indicated, and an additional point for each item that is correctly answered for both name and function. A perfect score which is three times the number of items in the test is possible under this method of scoring.

FIGURE 15 (continued)

PART PLACED HERE

The valve part for this item is the piston of the pressure regulating valve (Leslie CP type).

17

Part-Name	Function
1. Main valve	1. Aligns and supports lower crosshead.
2. Spring seat	2. Opens auxiliary valve when pushed by discharge pressure.
3. Diaphragm	3. Opens main valve when forced down by steam pressure admitted through controlling valve.
4. Piston	4. Provides a means of opening and closing steam ports.
5. Slide	5. Acts as a buffer and guide for adjusting spring.

Figure 5.—Sample card and valve part used in identification tests.

FIGURE 15 (continued)

Name ______________________________

Section __________ Date ____________

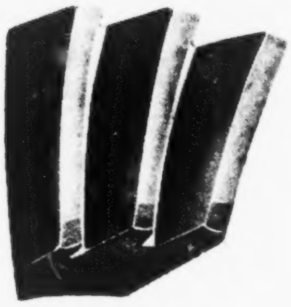
Station	Name	Function	Station	Name	Function
1	____	________	2	____	________
3	____	________	4	____	________
5	____	________	6	____	________
7	____	________	8	____	________
9	____	________	10	____	________
11	____	________	12	____	________
13	____	________	14	____	________
15	____	________	16	____	________
17	____	________	18	____	________
19	____	________	20	____	________
21	____	________	22	____	________
23	____	________	24	____	________
25	____	________	26	____	________
27	____	________	28	____	________
29	____	________			

ANSWER SHEET FOR THE VALVE IDENTIFICATION TEST

FIGURE 16

PART OF A PERFORMANCE TEST FOR AUTOMOBILE MECHANICS

(Sector of a Differential Ring Gear)



photograph of a section of a differential ring gear with a characteristic wear pattern. The examinee would have to 1) identify the part as a differential ring gear, 2) point out that it is wearing inconsistently, and 3) note that the damage has been caused by too much backlash. In this test the answers are recorded for evaluation at a later time. No clues are offered the examinee in the form of multiple-choice questions or lists of possible causes.

The test just described clearly discriminates between experienced mechanics and automotive parts men. Indeed, mean scores were found to be significantly different for four criterion groups. Automotive instructors made the highest scores; experienced mechanics and then by the parts men. (Comer, 1970)

Dr. Thomas Baldwin and his associates at North Carolina State University have devised an auditory identification test in the fields of automobile mechanics and machine shop practice. The examinee listens to recorded stimuli of equipment in operation and is required to identify the type of material being worked and to state whether the sounds are normal or abnormal. If the latter, he must then identify the cause of the malfunction from among the alternatives presented in a multiple-choice format. For example, in the test for machinists conditions such as the running speed, the speed of feeding the material to the tool, the materials being worked, the adjustment or sharpness and tightness of the cutting tools, and lubrication must be identified. An example of the choices for a machinists' test item is shown in Figure 17.

Variable Sequence Tests

When planning is an important aspect of performance, the instructor may wish to ascertain whether students know the proper sequence in which to do a job. A machinist with an object to fabricate must plan the job step by step if he is to do it in the most efficient way. There usually is a preferred sequence for machining the raw stock. Some operations must be completed before others can be initiated. Measurement of this planning function can be

FIGURE 17

SAMPLE MACHINIST AUDITORY ACHIEVEMENT TEST ITEM

Lathe turning mild steel, one inch in diameter, at 600 revolutions per minute

[Sound]

A. The speed is too low
B. The speed is too fast
C. The bit is dull
D. Proper cutting operation

accomplished by requiring the examinee to write down the sequences which he would use to perform the operations. In some instances these free-response answers may be scrambled and used as a basis for developing a structured checklist, with each item identified 1) as to whether it is necessary or not necessary to accomplish the task, and 2) as to its proper order in the sequence of operations.

In occupations where the diagnosis of malfunctions is an important activity, work-sample performance tests are often used to evaluate the effectiveness of training. Samples of such tests which utilize equipment have been discussed and are illustrated with Figures 6, 7, and 8. In some cases these diagnostic troubleshooting tasks have been simulated with printed material. More recently computers have been used for this prupose. Whichever approach is used, it is essential that there be a mechanism to reveal to the examinee the results of each test he performs so that he will know how successful he has been in isolating the malfunction.

In a typical troubleshooting test, the examinee is presented with a set of symptoms of the way the equipment is operating and then given a variety of options as to how he would proceed to diagnose the difficulty and/or isolate the defective component or components. This test must be structured in such a way that the examinee may select, at any time, the action he would take next. He is then informed as to the results of that action. Suppose a car will not start. The first thing the examinee might do is indicate that he wants to check the fuel supply. He would then be given a display of the fuel gauge indicating a nearly full tank. The examinee must then decide what he would do next and once again the results of his action should be revealed to him. With this added information he can proceed with further checks until he isolates the malfunction.

One of the earliest paper-and-pencil methods for testing sequential operations was the tab test described in Chapter III. Its name was derived from the fact that the examinee tore off a perforated tab each time he elected to carry out a specific action. The consequences of doing a specific thing were concealed beneath the tab. Of course the malfunction would ultimately be revealed if one were to pull all the tabs. However, diagnosis is most effective and efficient if it can be done with a minimum amount of trial and error. Therefore, a major element in scoring a tab test is counting the absolute number of tabs pulled. One may refine the scoring by requiring the examinee to record the order in which he pulls the tabs. This would make it possible to assess penalty points for conducting unnecessary checks or asking for unnecessary information. For example, if element C is working in a given instance, one need not run checks on elements A and B.

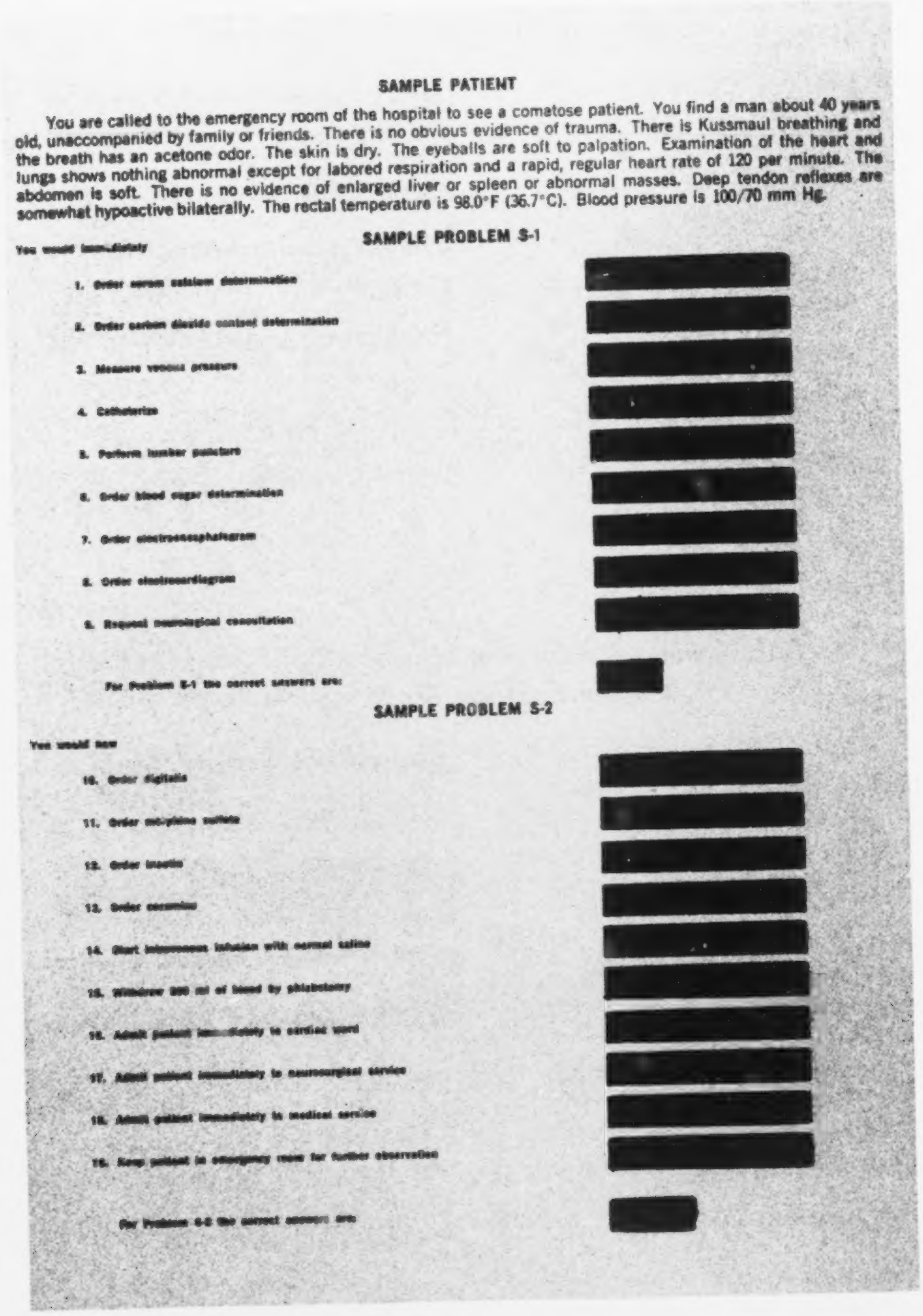
More recent developments have introduced an opaque erasable ink which is printed over the answers to be hidden. The overlay is removed simply by rubbing it with an ordinary pencil eraser. Another technique uses a special ink that is invisible until brushed with a liquid solution. The examinee moistens the space next to the option he thinks is appropriate and immediately learns the outcome.

Although the preceding discussion and most of the previous examples have been related to equipment malfunctions, Figure 18 is a sample problem from a test for physicians. The malfunctioning system is a human being, with the action leading to diagnosis and prescription. Figure 19 shows examples of responses revealed after erasure, and Figure 20 reproduces the instructions given to the examinees.

Some tests may require more elaborate supplementary printed material. For example, the "information booklet" accompanying a series of troubleshooting tests for a complex Navy electronic system includes an introduction to the test format; statements of assumptions, abbreviations, and symbols; notes on miscellaneous

FIGURE 18

SAMPLE PROBLEM,
VARIABLE SEQUENCE FORMAT, ERASABLE OVERPRINT



SAMPLE PATIENT

You are called to the emergency room of the hospital to see a comatose patient. You find a man about 40 years old, unaccompanied by family or friends. There is no obvious evidence of trauma. There is Kussmaul breathing and the breath has an acetone odor. The skin is dry. The eyeballs are soft to palpation. Examination of the heart and lungs shows nothing abnormal except for labored respiration and a rapid, regular heart rate of 120 per minute. The abdomen is soft. There is no evidence of enlarged liver or spleen or abnormal masses. Deep tendon reflexes are somewhat hypoactive bilaterally. The rectal temperature is 98.0°F (36.7°C). Blood pressure is 100/70 mm Hg.

SAMPLE PROBLEM S-1

You would immediately

1. Order serum calcium determination
2. Order carbon dioxide content determination
3. Measure venous pressure
4. Catheterize
5. Perform lumbar puncture
6. Order blood sugar determination
7. Order electroencephalogram
8. Order electrocardiogram
9. Request neurological consultation

For Problem S-1 the correct answers are:

SAMPLE PROBLEM S-2

You would now

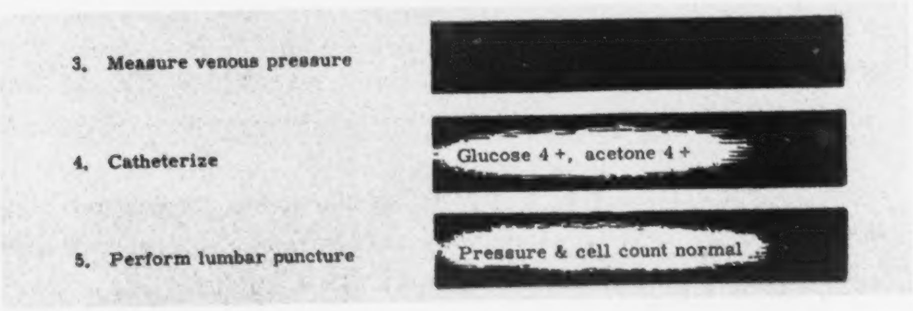
10. Order digitalis
11. Order morphine sulfate
12. Order insulin
13. Order coramine
14. Start intravenous infusion with normal saline
15. Withdraw 500 ml of blood by phlebotomy
16. Admit patient immediately to cardiac ward
17. Admit patient immediately to neurosurgical service
18. Admit patient immediately to medical service
19. Keep patient in emergency room for further observation

For Problem S-2 the correct answers are:

FIGURE 19

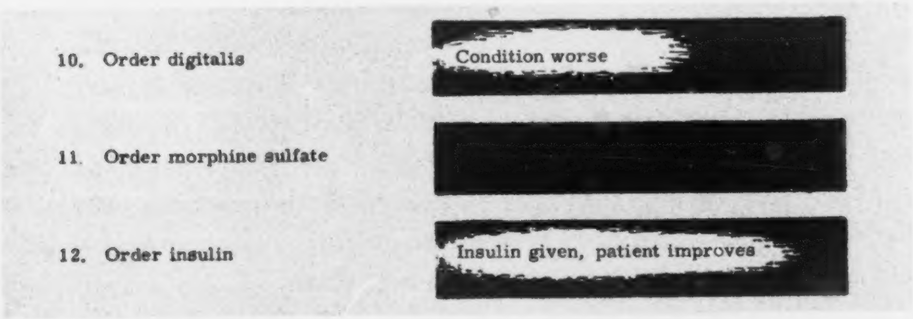
EXAMPLES OF ERASABLE OVERPRINT ITEM RESPONSES

Enlargement of Items 3, 4, *and* 5 *of Sample Problem*
Showing Erasures for Items 4 *and* 5



3. Measure venous pressure	
4. Catheterize	Glucose 4 +, acetone 4 +
5. Perform lumbar puncture	Pressure & cell count normal

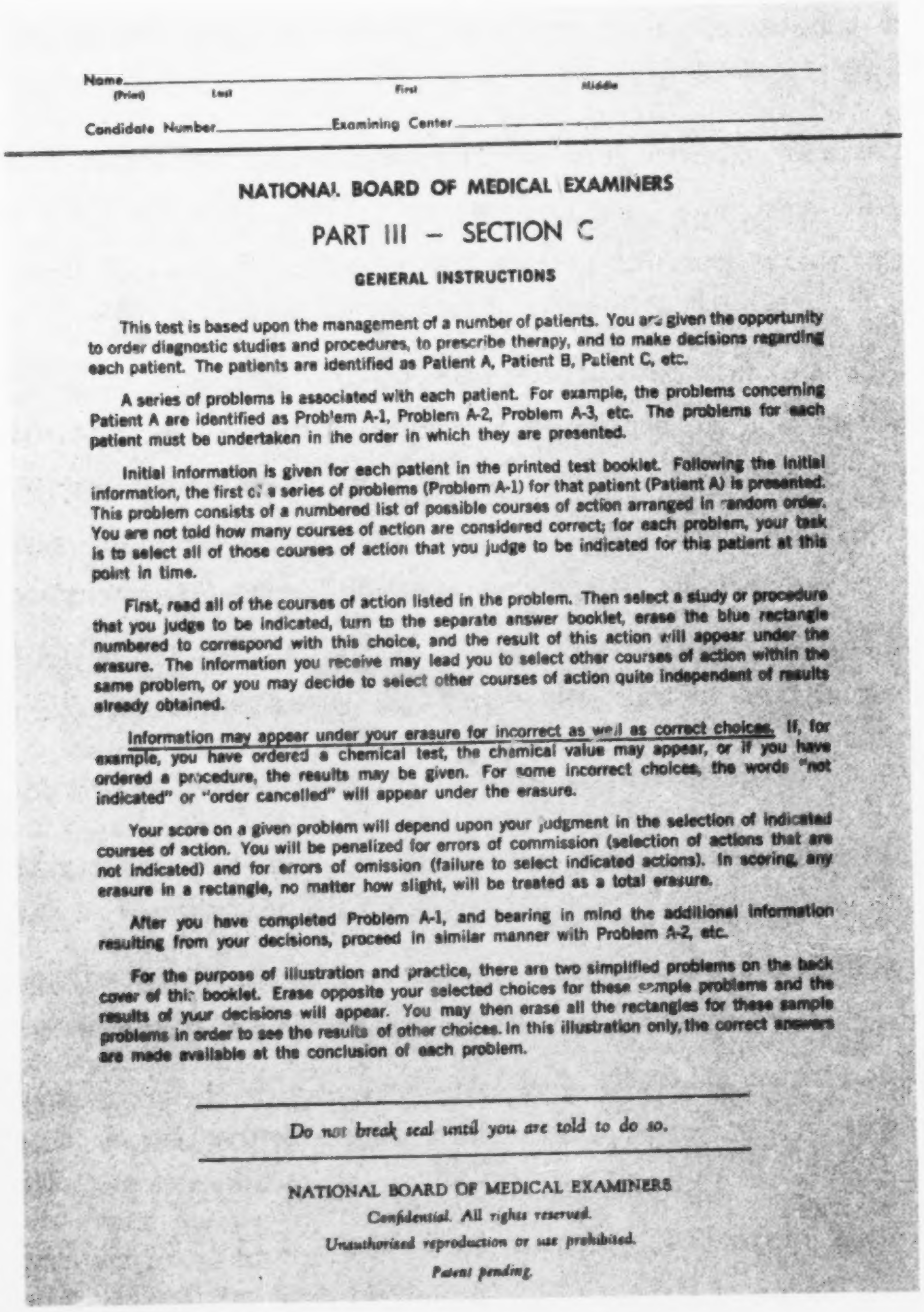
Enlargement of Items 10, 11, *and* 12 *of Sample Problem*
Showing Erasures for Items 10 *and* 12



10. Order digitalis	Condition worse
11. Order morphine sulfate	
12. Order insulin	Insulin given, patient improves

FIGURE 20

FRONT COVER OF TEST BOOKLET
WITH DETAILED INSTRUCTIONS FOR THE CANDIDATE



Name (Print) ________________ Last ________________ First ________________ Middle

Candidate Number ________________ Examining Center ________________

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PART III – SECTION C

GENERAL INSTRUCTIONS

This test is based upon the management of a number of patients. You are given the opportunity to order diagnostic studies and procedures, to prescribe therapy, and to make decisions regarding each patient. The patients are identified as Patient A, Patient B, Patient C, etc.

A series of problems is associated with each patient. For example, the problems concerning Patient A are identified as Problem A-1, Problem A-2, Problem A-3, etc. The problems for each patient must be undertaken in the order in which they are presented.

Initial information is given for each patient in the printed test booklet. Following the initial information, the first of a series of problems (Problem A-1) for that patient (Patient A) is presented. This problem consists of a numbered list of possible courses of action arranged in random order. You are not told how many courses of action are considered correct; for each problem, your task is to select all of those courses of action that you judge to be indicated for this patient at this point in time.

First, read all of the courses of action listed in the problem. Then select a study or procedure that you judge to be indicated, turn to the separate answer booklet, erase the blue rectangle numbered to correspond with this choice, and the result of this action will appear under the erasure. The information you receive may lead you to select other courses of action within the same problem, or you may decide to select other courses of action quite independent of results already obtained.

Information may appear under your erasure for incorrect as well as correct choices. If, for example, you have ordered a chemical test, the chemical value may appear, or if you have ordered a procedure, the results may be given. For some incorrect choices, the words "not indicated" or "order cancelled" will appear under the erasure.

Your score on a given problem will depend upon your judgment in the selection of indicated courses of action. You will be penalized for errors of commission (selection of actions that are not indicated) and for errors of omission (failure to select indicated actions). In scoring, any erasure in a rectangle, no matter how slight, will be treated as a total erasure.

After you have completed Problem A-1, and bearing in mind the additional information resulting from your decisions, proceed in similar manner with Problem A-2, etc.

For the purpose of illustration and practice, there are two simplified problems on the back cover of this booklet. Erase opposite your selected choices for these sample problems and the results of your decisions will appear. You may then erase all the rectangles for these sample problems in order to see the results of other choices. In this illustration only, the correct answers are made available at the conclusion of each problem.

Do not break seal until you are told to do so.

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Patent pending.

operating and troubleshooting data which are referenced from the problem sheets; sketches of nine machine front panel configurations (various combinations of on, off, and flashing indicator lights); and 94 pictures and specifications of electronic wave forms that would be observed on an oscilloscope. Figure 21 reproduces one page of the wave forms. The information booklet is used to determine the result of an action the examinee selects on the problem sheet. When the examinee erases the overlay he sees the reference number for the corresponding item in the information booklet.

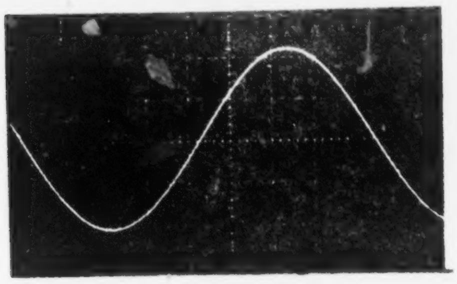
The rather elaborate printing requirements for the two tests just discussed and the perforating requirements for the tab test would seem to rule out the use of these types of tests in all but large-volume, well-financed programs. Not so! The simplest variable-sequence format involves putting each choice on one side of a card and the consequence of the choice on the other side. Slightly more complicated to assemble, but much more secure, and suitable for group testing is the use of a sealed envelope for each choice, with the choice written on the outside, and the consequence on a slip of paper inside. Tearing open the envelope is as irreversible as pulling a tab or erasing an overprint.

Simulators

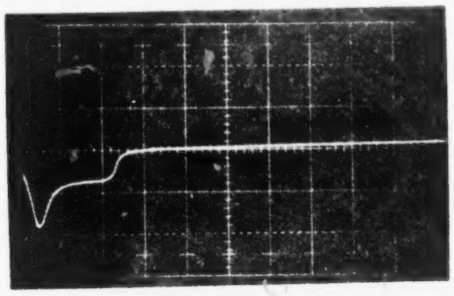
Simulators are often thought of as the ultimate in performance testing, especially in situations where the actual equipment cannot be used for job sample tests. When the term simulator is used, it usually conjures up visions of the highly complex simulators that have been widely publicized in the aerospace industry and in the aircraft industry. It is common knowledge that the astronauts practiced for the moon shot in high-fidelity simulators. Even before the huge 747 plane had been flight-tested, commercial airline pilots were flying 747 simulators so that they would be familiar with the controls of the actual plane when it was finished and became operational. There is no doubt in anyone's mind that such simulators offer tremendous benefits to the user. They make

FIGURE 21

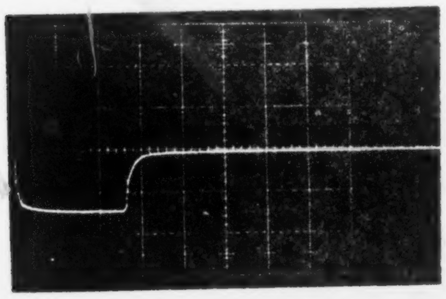
EXAMPLE OF REFERENCES IN THE INFORMATION BOOKLET ACCOMPANYING A VARIABLE SEQUENCE PERFORMANCE TEST



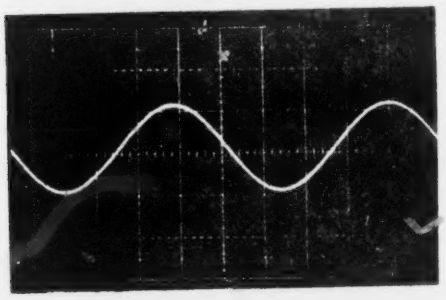
#161 Vert. Sens. - 2 v/cm
Sweep Time - 2 ms/cm



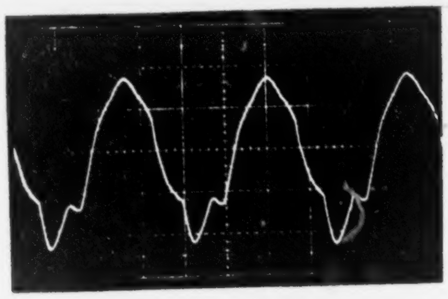
#162 Vert. Sens. - 5 v/cm
Sweep Time - 20 usec/cm



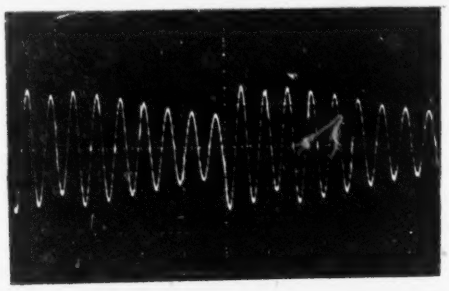
#163 Vert. Sens. - 10 v/cm
Sweep Time - 20 usec/cm



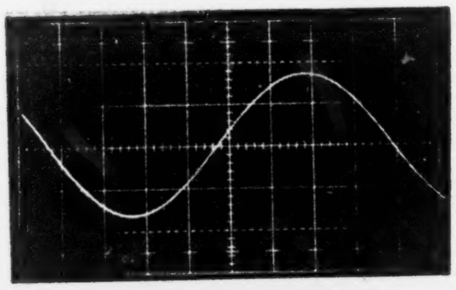
#164 Vert. Sens. - 0.5 v/cm
Sweep Time - 0.5 ms/cm



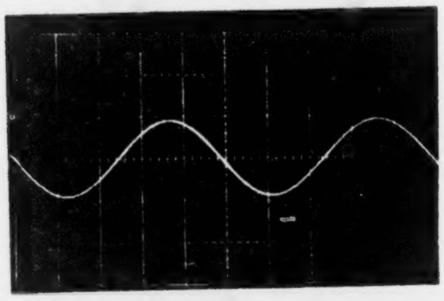
#165 Vert. Sens. - 10 v/cm
Sweep Time - 5 ms/cm



#166 Vert. Sens. - 20 v/cm
Sweep Time - 20 usec/cm



#167 Vert. Sens. - 1 v/cm
Sweep Time - 2 ms/cm
Note - S1



#168 Vert. Sens. - 10 v/cm
Sweep Time - 0.2 usec/cm

it possible for training to take place before the operational equipment is ready. They eliminate the danger of damage to equipment and injury to personnel which might result from attempts to train individuals using the actual equipment.

While the popular conception of simulators nearly always relates to highly complex, sophisticated, and expensive equipment, simulators need not fit this description. Some are relatively simple and inexpensive. For example, the simulator shown in Figure 22 is one that is used to determine whether an electrical technician can make accurate measurements of electrical voltage, current, and resistance by using appropriate instruments. This type of task is a component of many technical occupations. By using a compact simulator to reproduce various electrical circuits, it is possible to test the ability of the technician to use appropriate test instruments. The numbered units in Figure 22 are resistors; the connectors are low-resistance metal straps. Examples of problems involving these are:

1. What is the resistance between I and J?
2. What is the voltage drop between D and J?

Another rather simple simulator is shown in Figure 23. This one was designed to test the ability of aviation electricians to install wiring in a given area according to a schematic diagram. On the right of Figure 23 is the unwired work area; on the left is the correctly wired simulator. The wiring diagram is shown in Figure 24. The simulator represents an aircraft section and contains dummy electrical units and aircraft components.

Several other simple simulators are described in the Portfolio of Performance Tests included in the appendix.

Increasingly, commercially developed simulators are finding their way into vocational schools and industrial training programs. Simulators have been developed for training and testing troubleshooting skills in such areas as electronic equipment, diesel engines, and household appliances. A simulator, by Omnidata, Inc., used for training automobile mechanics is shown in Figure 43. Examples of devices for simulating the operation of, malfunctions of,

FIGURE 22

AN ELECTRICAL CHECKS TESTING BOX

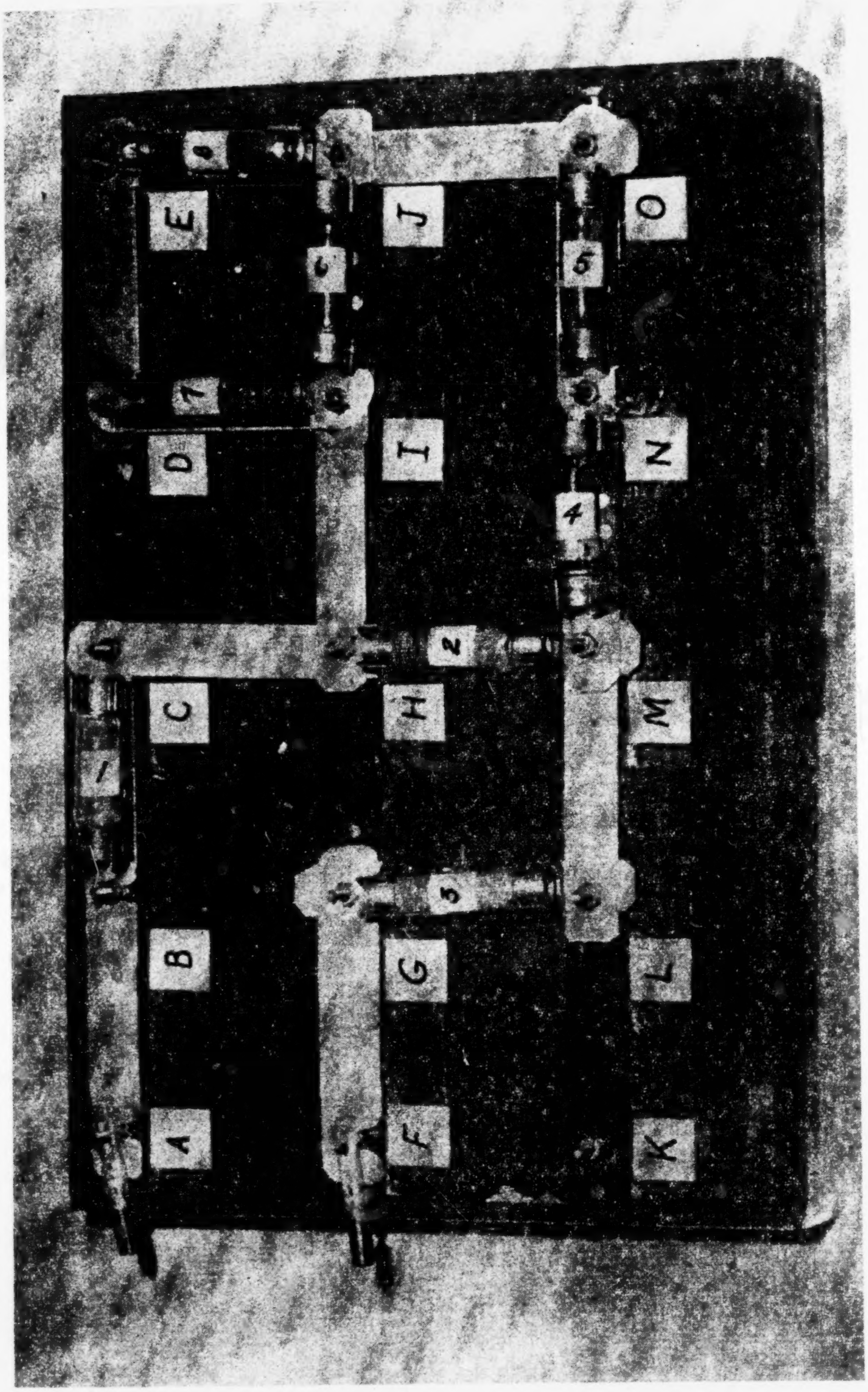

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
1
2
3
4
5
6
7

FIGURE 23

BASIC SKILLS TEST BOXES

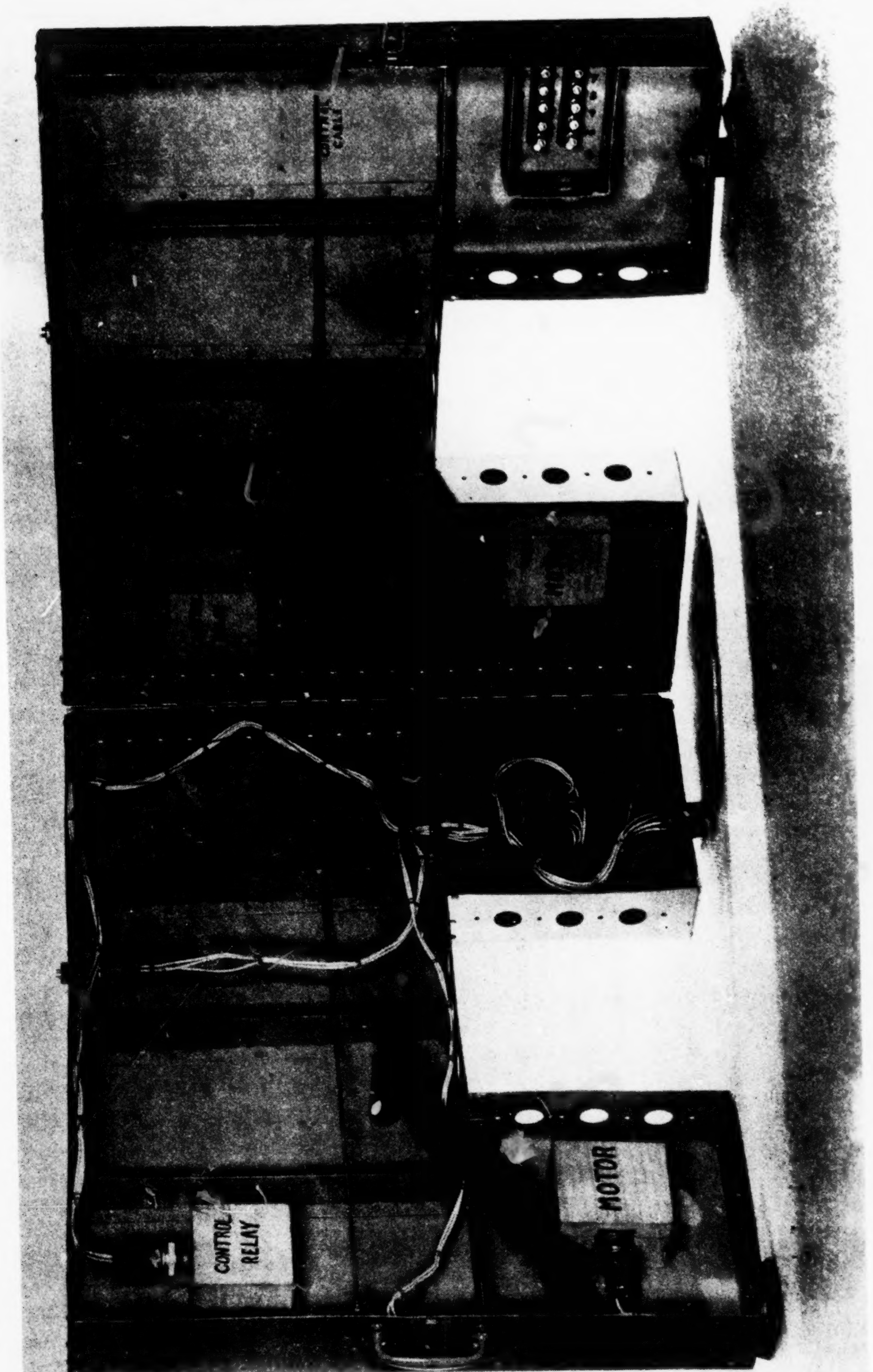

CONTROL CABLE
CONTROL RELAY
MOTOR

FIGURE 24

SCHEMATIC FOR A BASIC SKILLS TEST

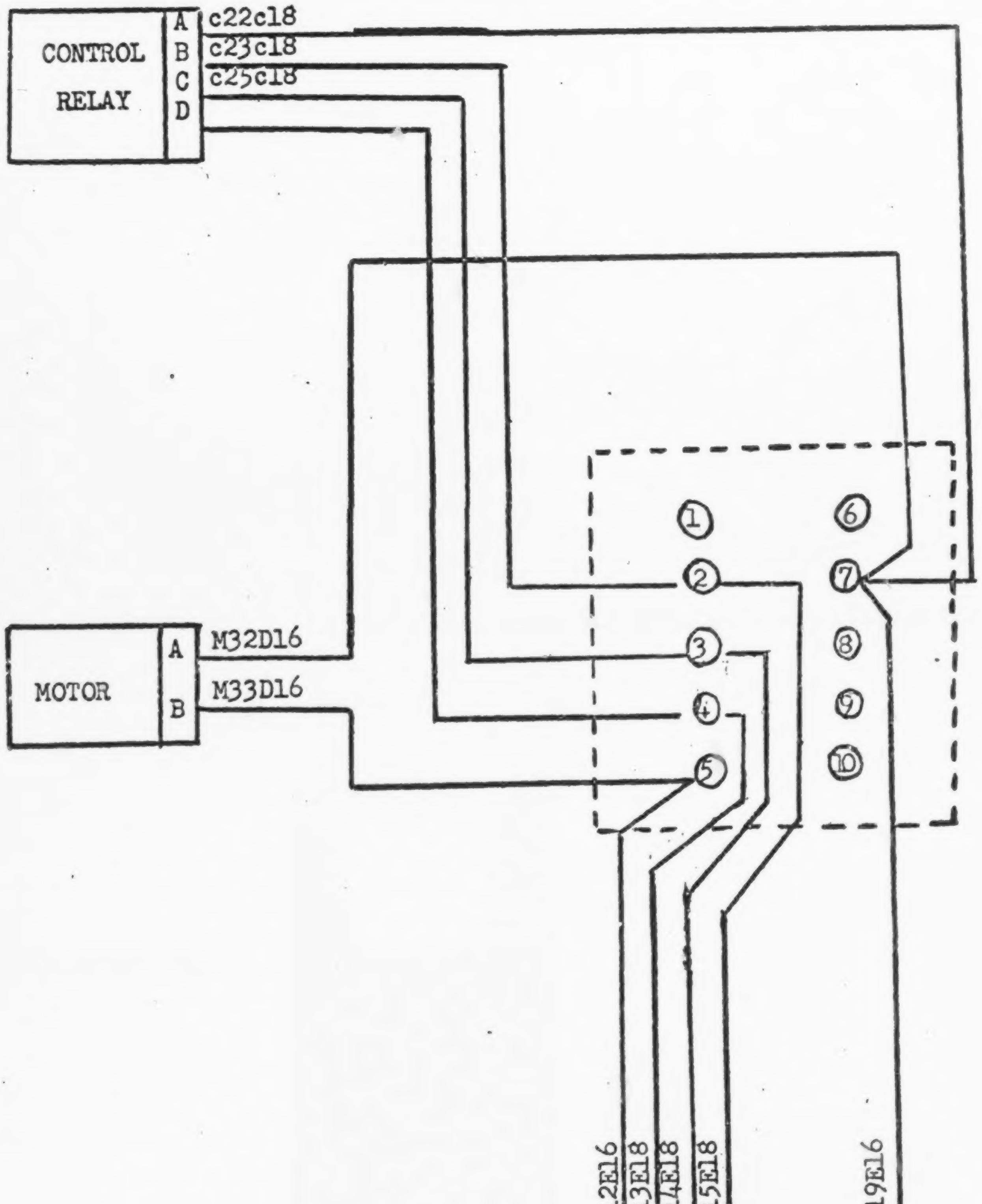
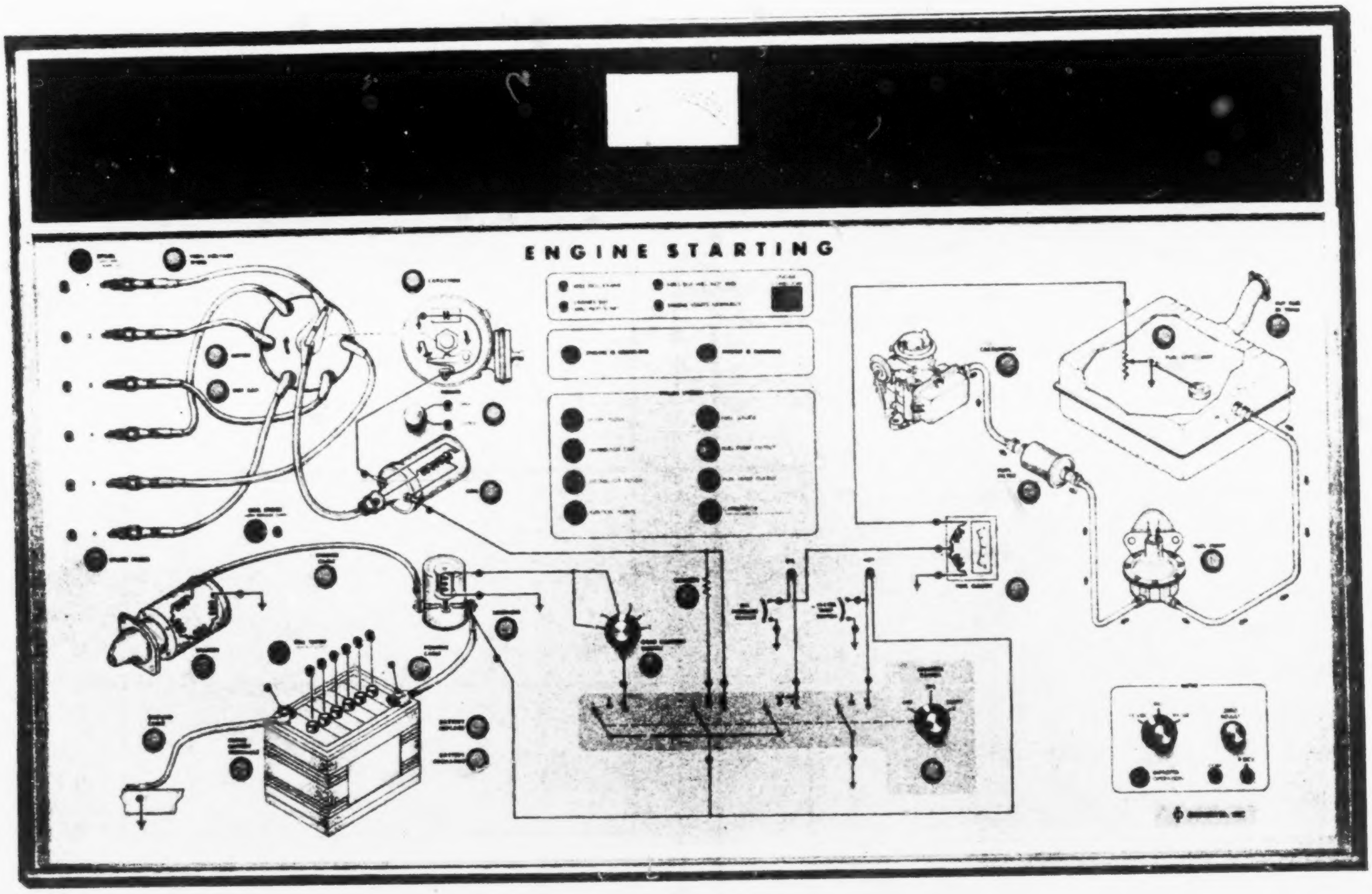
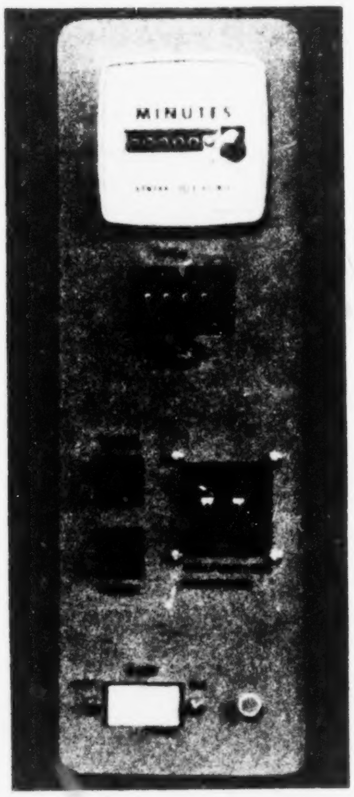

CONTROL RELAY
A
B
C
D
c22c18
c23c18
c25c18
MOTOR
A
B
M32D16
M33D16
1
2
3
4
5
6
7
8
9
10
J12E16
J13E18
J14E18
J15E18
J19E16
A B C D E F G H

FIGURE 25

AN AUTOMOBILE ELECTRICAL CIRCUIT SIMULATOR


ENGINE STARTING

STUDENT'S PANEL



INSTRUCTOR'S PANEL

and troubleshooting performance for an automatic clothes washer and a transistor radio will be found in the Portfolio of Performance Tests in the appendix.

The student panel for the automative simulator shown in Figure 25 reproduces the essential operations of a current model automobile with a four-stroke internal combustion engine. It is capable of simulating normal operations and twenty-eight different malfunctions. (See the malfunction list in Figure 26.) The student panel is equipped with a variety of pushbuttons, indicators, and controls--each directly related to the schematic diagram representing various components of the automobile. All operating controls of the actual machine appear on the simulator. Every setting of every control duplicates the conditions prevailing throughout the circuits of the actual machine under the same conditions. The pushbuttons are used to "replace" suspected defective parts. Visual aids are also provided in the form of appropriately illuminated indicators and transparencies.

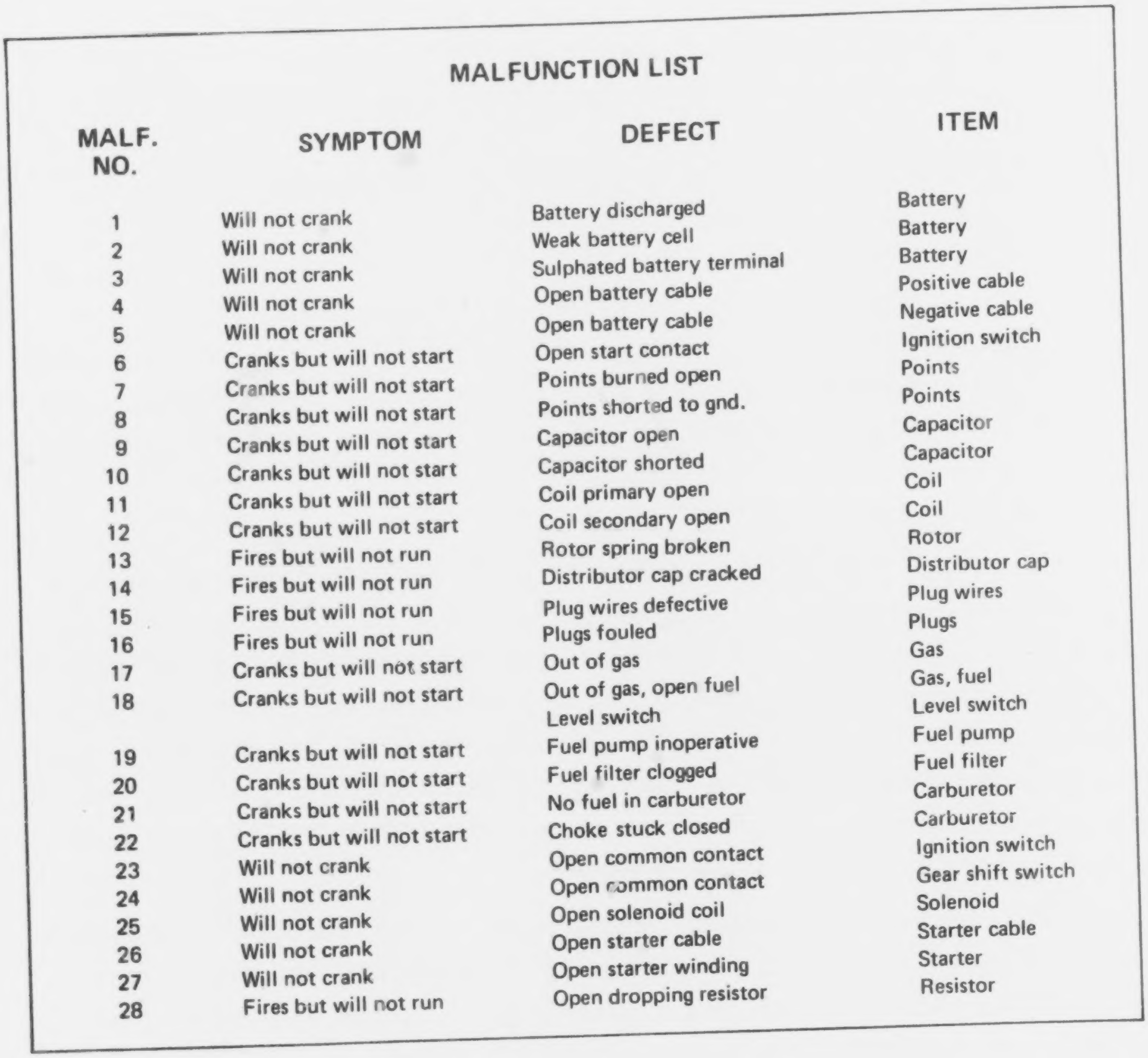
The student's panel includes test points on "both sides" of every electrical part. In conjunction with a built-in multimeter the student may measure the voltage or resistance readings between any two points in the machine under any combination of machine malfunction control settings. Troubleshooting can be taught and practiced by voltage test methods, resistance test methods, or a combination of both. These readings may be normal or abnormal, according to the fault in the system.

The instructor's panel includes an ON/OFF switch, an elapsed-time indicator, a REPLACE counter, and "conditions controls" consisting of a two-digit selector switch plus INSERT and RESET pushbuttons. To operate, one sets the ON/OFF switch to ON. Normal operation will be simulated.

To insert a malfunction, one sets the two-digit selector switch to the desired malfunction (see the malfunction list) and then presses the insert pushbutton. The elapsed time indicator will

FIGURE 26

MALFUNCTION LIST
FOR AUTOMOBILE ELECTRICAL CIRCUIT SIMULATOR



MALFUNCTION LIST

MALF. NO.	SYMPTOM	DEFECT	ITEM
1	Will not crank	Battery discharged	Battery
2	Will not crank	Weak battery cell	Battery
3	Will not crank	Sulphated battery terminal	Battery
4	Will not crank	Open battery cable	Positive cable
5	Will not crank	Open battery cable	Negative cable
6	Cranks but will not start	Open start contact	Ignition switch
7	Cranks but will not start	Points burned open	Points
8	Cranks but will not start	Points shorted to gnd.	Points
9	Cranks but will not start	Capacitor open	Capacitor
10	Cranks but will not start	Capacitor shorted	Capacitor
11	Cranks but will not start	Coil primary open	Coil
12	Cranks but will not start	Coil secondary open	Coil
13	Fires but will not run	Rotor spring broken	Rotor
14	Fires but will not run	Distributor cap cracked	Distributor cap
15	Fires but will not run	Plug wires defective	Plug wires
16	Fires but will not run	Plugs fouled	Plugs
17	Cranks but will not start	Out of gas	Gas
18	Cranks but will not start	Out of gas, open fuel Level switch	Gas, fuel Level switch
19	Cranks but will not start	Fuel pump inoperative	Fuel pump
20	Cranks but will not start	Fuel filter clogged	Fuel filter
21	Cranks but will not start	No fuel in carburetor	Carburetor
22	Cranks but will not start	Choke stuck closed	Carburetor
23	Will not crank	Open common contact	Ignition switch
24	Will not crank	Open common contact	Gear shift switch
25	Will not crank	Open solenoid coil	Solenoid
26	Will not crank	Open starter cable	Starter cable
27	Will not crank	Open starter winding	Starter
28	Fires but will not run	Open dropping resistor	Resistor

run and attempted repairs by simulated part replacement will be tallied by the REPLACE counter. When the proper part is "replaced," the elapsed time indicator stops and operation returns to normal. Any malfunction is immediately cleared when the RESET pushbutton is pressed. Both the REPLACE counter and the elapsed time indicator are manually reset at the indicator. One defective part is simulated by each position of the malfunction selector. Thus this simulator measures the time required to identify the defective parts and the number of replacements tried until the proper defective part is identified. Both are valid indicators of troubleshooting ability.

It is obvious that simulators of the sort just described have both advantages and disadvantages. They are quick and easy to use, they do represent important elements of the troubleshooting task, and they can be used in locations where the real equipment cannot. They suffer from their representing only part of the total real environment. For example, the competent auto mechanic hears the way an engine runs--or fails to run; he feels and sees differences in the vibrations of the engine under varying operating conditions; he is cued by the presence or absence of gasoline odors.

A Final Word: Readers who are familiar with the sets of rules and principles for writing multiple-choice test items may feel uncomfortable because the exact "right" and "wrong" ways of preparing performance tests have not been prescribed. Human performance covers such a wide range of behaviors that a variety of techniques must be employed to test them. No set of rules or cookbook approach can be adequate to define the boundaries of acceptable performance. Therefore, the state of the art of performance testing has been no more than sampled to give the reader an introduction to effective practices that can be adapted to many vocational and technical occupational areas.

APPENDIX

A PORTFOLIO OF PERFORMANCE TESTS

The following pages present a wide sampling of performance tests. They are varied in their formats and in their subject matter. Some are extremely detailed and complete; others are somewhat abbreviated. All of them, however, represent performance tests that have been developed to serve an operational purpose--either in research or in training. In some cases only part of a longer test is shown, or only that part which was included in a research report.

These tests have not been edited or revised for this *Handbook*. In a few cases, identifying information has been removed at the request of the supplier. The tests have been selected to represent a wide range of skills and occupations.

PERFORMANCE TEST

Bench Woodwork*

This is a test of the examinee's ability to fabricate a relatively simple wooden object, using simple hand tools and a block of wood approximately five inches by ten inches by one inch. The test evaluates all three scoring dimensions: product, process, and time required. It is unusual in the very large number of check points that are included--126, with a total of 834 weighted points as the maximum score.

The test is from the text, *Measuring Educational Achievement*, one of the very few nonmilitary references to give more than passing attention to performance testing. There are two excellent chapters: "Object Tests," which covers identification tests, and "Manipulative Performance Tests." Both chapters include many examples and illustrations.

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*William J. Micheels and M. Ray Karnes. *Measuring Educational Achievement.* New York: McGraw-Hill Book Company, Inc., 1950, pages 354-364. Copyright 1950, McGraw-Hill Book Company, Inc. Reproduced by permission.

PERFORMANCE TEST: BENCH WOODWORK

Name ______________________________ Date __________
Class _____ Section _____ Instructor _______________
Possible Score:
Time 100 Procedure 236 Quality of work 498 Total 834
Student's Score:
Time ____ Procedure ____ Quality of Work ____ Total ____

Directions

A. To the Student:

1. Read these directions carefully. Study the drawing and specifications for the job you are to perform. Obtain from your instructor an explanation of all directions which are not clear to you. Your instructor will tell you when to start to work.

2. The purpose of this test is to measure how well you can perform the basic operations included in the job described below. In completing these operations you are to follow the procedures demonstrated and taught by your instructor.

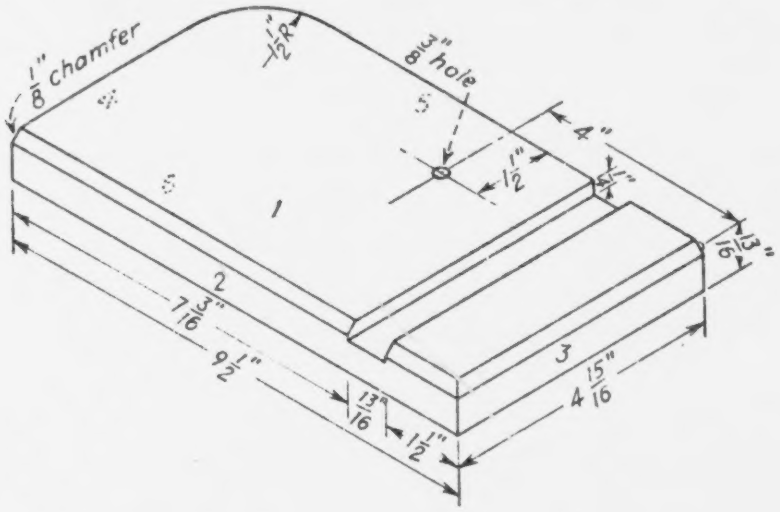
3. The amount of time required, the procedures followed, and the quality of the finished work will be considered in evaluating your performance. By completing the job in 30 minutes or less, you can earn a total of 100 points for time. Five points will be deducted for each minute required beyond 30. You must stop if you have not finished by the end of 50 minutes. You can earn 236 points by following the correct procedure in every detail. You will receive an additional 498 points if your finished work meets all standards of accuracy and quality. To obtain the highest possible score, follow the proper procedures and work as accurately and rapidly as you can. Plan to finish the test.

4. When the instructor tells you to start, proceed as follows:
    a. Leave the surfaces marked, "1," "2," and "3" as they are. Finish working the stock to dimensions. Finish surfaces 4, 5, and 6 by planing, and number them in the order finished.
    b. Lay out and cut the dado.
    c. Locate and bore the hole.
    d. Lay out, cut, and pare the curve.
    e. Lay out and cut the chamfer.
    f. Turn in your work to your instructor when you have finished.

Note: These directions and the drawing and specifications will be available to you while you take the test.

Specifications: To be made of straight-grain, plain-sawed yellow poplar, basswood, or white pine. Stock to be issued: 7/8" x 5 1/16" x 9 15/16", with surfaces 1, 2, and

3 accurately planed true, straight, free of wind, and 90° to each other. Saw, chisel, and plane cuts to be made to center of layout lines. No sanding permitted.



Working drawing and specifications for the test block.

B. To the Examiner:

1. Prepare the work stations prior to the arrival of the students. At each station arrange the following in a uniform and orderly manner:

a. Back saw
b. Set of chisels
c. Set of auger bits
d. Try or combination square
e. Brace
f. Marking gauge
g. Rule
h. Dividers or compass
i. Bench hook
j. Jack plane
k. Knife
l. Hard and soft pencils
m. Chamfer stick
n. T bevel
o. Hammer
p. Mallet
q. A set of directions to the student, drawing, and specifications
r. A piece of stock as required
s. A scrap of the same stock

2. Instruct the student to study the directions carefully. Ask appropriate questions to make sure that he understands what to do.

3. Direct the student to begin work and record the time. Also record the time at the start and completion of each major phase of the performance.

4. As the student works, execute, with as little interference as possible, the appropriate check list.

5. If the student at any point clearly makes, or is about to make, an error which will prevent his completing the test, or a major phase of it, instruct him as to the proper procedure at that point but allow him no credit, on the procedure check list, for the specific steps which required your assistance.

RECORD OF TIME CONSUMED AND CREDIT EARNED FOR TIME

Operation	Time Started	Time Completed	Minutes Required
1. Complete squaring of stock			
2. Lay out and cut dado			
3. Locate and bore hole			
4. Lay out, cut, and pare curve			
5. Lay out and cut chamfer			

Total time to the nearest minute ____________________
Points earned for time ____________________
(Allow 100 points if work is completed in 30 minutes or less. Deduct 5 points for each minute over 30.)

PROCEDURE CHECK LIST

(To be executed while student performs.)

Item of Work	Maximum Credit	Credit Earned
I. Completes squaring of stock		
A. Works stock to length as first step . .	5	
1. Stands rule on edge to measure length; keeps rule parallel to edge of stock	2	
2. Measures from 1" mark	2	
3. From edge 2 squares line across face 1.	2	
4. From face 1 squares lines across edges 2 and 5	2	
5. Connects lines across face 6. . . .	2	
6. Makes all lines with knife or hard pencil.	2	
7. Makes light lines and does not retrace	2	
8. To cut, places stock in vise or bench hook with face 1 up	2	
9. Saws from edge 2.	2	
10. Starts saw smoothly	2	

Item of Work	Maximum Credit	Credit Earned
11. Checks alignment of saw	2	
12. Takes long, free strokes.	2	
13. Holds surplus stock and lightens stroke to prevent splitting at finish of cut	2	
14. Saws outside of line but leaves no more than 1/16" for planing	2	
15. To plane end, places stock low in vise with end parallel to bench top	2	
16. Checks and/or adjusts plane, using scrap	2	
17. Takes light, shearing cuts.	2	
18. Exercises proper precautions against splitting edges	2	
19. Planes to center of layout lines; checks.	2	
B. Works stock to width immediately after getting length.	5	
1. Checks setting of marking gauge with rule	2	
2. Gauges light, uniform, continuous lines	2	
3. Gauges lines on both 1 and 6. . . .	2	
4. Places stock low in vise with edge horizontal.	2	
5. Takes heavy cuts to remove surplus.	2	
6. Checks frequently	2	
7. All cuts taken with grain	2	
8. Removes full shaving with last cut.	2	
9. Planes to center of gauged lines. .	2	
C. Works stock to thickness immediately after width	5	
1. Checks setting of marking gauge with rule	2	
2. Lays off thickness on both edges and ends.	2	
3. Places stock either flat on bench between vise dog and bench stop or horizontal in vise.	2	
4. Takes heavy cuts to remove excess stock	2	
5. Reduces cut and planes to center of gauged lines.	2	
6. Checks frequently	2	
7. All cuts taken with grain	2	
Total points for squaring stock	85	

Item of Work	Maximum Credit	Credit Earned
II. Lays out and cuts dado		
1. Measures from end 3 to locate dado . .	2	
2. Rule on edge parallel to edge of stock.	2	
3. Measures from 1" mark.	2	
4. Locates both sides of dado without moving rule.	2	
5. From edge 2 squares lines across face 1.	2	
6. From face 1 squares lines across edges 2 and 5 at each side of dado	2	
7. Uses knife or hard pencil for layout, except for depth lines	2	
8. Gauges depth lines with marking gauge.	2	
9. Checks setting of gauge with rule. . .	2	
10. Locates stock in vise with face 1 horizontal	2	
11. Located dado so as to prevent striking metal with saw	2	
12. Saws inside and to center of lines across face.	2	
13. Saw kerfs made uniform in depth and to center of depth lines.	2	
14. Selects chisel of proper width	2	
15. Chisels with bevel up.	2	
16. Places edge of chisel slightly above depth lines to remove surplus stock. .	2	
17. Chisels from both edges to prevent splitting.	2	
18. Uses wooden mallet to drive chisel . .	2	
19. Pares dado to uniform depth to center of gauged lines.	2	
20. Keeps hands from in front of cutting edge	2	
Total points for laying out and cutting dado. .	40	
III. Locates and bores hole		
1. With rule on edge measures distance from edge 2 and end 3.	2	
2. Measures from 1" mark.	2	
3. With square and pencil lays off light pencil lines whose intersection locates center of whole.	2	
4. Clamps stock in vise horizontally. . .	2	
5. Selects bit of proper size	2	
6. Positions stock to prevent bit from striking metal	2	

Item of Work	Maximum Credit	Credit Earned
7. Starts screw in wood and inspects hole to check location.	2	
8. Holds brace steady and erect	2	
9. Checks alignment	2	
10. Stops bit when screw pierces back side	2	
11. Reverses stock and completes hole from side 6	2	
12. Exercises precaution to prevent splitting as hole is finished	2	
Total points for locating and boring hole . . .	24	
IV. Lays out, cuts, and pares curve		
1. Measures from edge 2 and end 3 to locate center of arc	2	
2. Places rule on edge and measures from 1" mark.	2	
3. With square and pencil lays off light lines whose intersection locates center of arc.	2	
4. Sets and checks dividers or compass. .	2	
5. Scribes light, uniform arc	2	
6. Arc is tangent to end and edge	2	
7. Projects lines from center or measures with rule to determine exact points of tangency	2	
8. Squares lines across end and edge at points of tangency	2	
9. Removes excess stock with saw or with heavy cuts with chisel	2	
10. With 1" chisel, pares curve to center of layout line	2	
11. Keeps bevel up or away from stock. . .	2	
12. Checks for squareness and pares curve until curved edge is square with face 1	2	
13. Keeps hands from in front of cutting edge	2	
Total points for laying out, cutting, and paring curve.	26	
V. Lays out and cuts chamfer		
1. Measures distance from arris to locate chamfer line at one point only	2	
2. Gauges lines by hand or with chamfer stick.	2	

Item of Work	Maximum Credit	Credit Earned
3. Gauges lines with hard pencil, not knife or marking gauge	2	
4. Cuts chamfer along edge first.	2	
5. Takes deep, continuous cuts to remove surplus.	2	
6. Planes with grain.	2	
7. Lightens cut to finish	2	
8. Checks frequently as lines are approached	2	
9. Removes full, uniform shaving on last cut.	2	
10. Places stock low in vise to plane end chamfer.	2	
11. Planes toward chamfered edge	2	
12. Takes shearing cuts.	2	
13. Takes light, continuous cuts to finish	2	
Total points for laying out and cutting chamfer	26	
VI. Demonstrates general competence		
1. Approaches problem deliberately and with confidence	5	
2. Shows evidence at all times of knowing what to do and how to do it	5	
3. Keeps tools orderly arranged.	5	
4. Exercises care in handling tools; permits no cutting edge to strike metal	5	
5. Grasps edge tools by handles, not cutting edges	5	
6. Drops no tools.	5	
7. Keeps hands from in front of cutting edges	5	
Total points for general competence	35	
Total points for procedure.	236	

QUALITY CHECK LIST

(To be used to record results of evaluation of completed work.)

I. Measurements and dimensions

Directions:

1. In checking errors in linear measurements and dimensions, use 1/64" as the unit of measurement.

2. In checking errors in angular measurement, use 1/2° as the unit of measurement.

3. This check list has been designed to penalize the student: (a) one point for each unit of error made in a direction that will permit correction without spoiling the stock, (b) two points for each unit of error that will not permit correction without spoilage of stock, and (c) two points for each unit of difference between the extremes of a given dimension or measurement. Items of work which bear a penalty of two points per unit of error are marked with an asterisk.

4. In determining penalty for "excess," measure a given student's work at point of greatest distance or at point of largest angle. If the dimension or angle exceeds at no point the specified dimensions or angle the student draws no penalty for this item in the "excess" column.

5. To determine the penalty for "shortage," take measurement at the point of shortest distance or smallest angle. The student draws no penalty in the "shortage" column on items that do not at any point fall under specified dimensions or angles.

6. A double penalty should be given for variations in dimensions. From the measurement taken at the point of greatest distance subtract the measurement taken at the point of shortest distance. Convert the difference to units of error and multiply by two. For example, if the thickness measures 49/64" at the thickest point and 47/64" at the thinnest point the difference is 1/32" (2 units of error) and the total penalty for variation is four.

7. Likewise, subtract the smallest reading from the largest reading for a given angle, convert to units of error, and multiply by two to obtain the penalty for a variation in that angle. If a given angle measures 91° at point of the largest reading and 89 at the point of the smallest, there is a variation of 4 units of error for which the student draws a penalty of 8.

8. Use combination square and bevel protractor for linear and angular measurements.

9. To measure angle of hole, insert a dowel in the hole and measure angle at point of greatest variation.

10. Use template constructed of sheet steel and small numbered drills to check curve.

11. Use surface plate and gauge to test thickness at points other than along ends and edges.

12. Except for thickness as measured with surface plate and gauge, take all measurements from and along or across surfaces 1, 2, and 3.

Measurement	Penalty for Excess		Penalty for Shortage		Penalty for Variation		Credit	
	Maximum	Net	Maximum	Net	Maximum	Net	Maximum	Net
Thickness as measured across ends and edges . .	8		16*		16*		40	
Thickness at points on surface 6. . .	4		8*		8		20	
Width.	8		16*		16*		40	
Length	8		16*		16*		40	
Dado from end 3.	4		4		8*		16	
Width of dado along surface 1.	8*		4		8*		20	
Depth of dado	16*		8		16*		40	
Edge 2 from layout line for hole . . .	4		4		...		8	
End 3 from layout line for hole . . .	4		4		...		8	
Edge of hole from edge 2. .	4		4		...		8	
Edge of hole from end 3 . .	4		4		...		8	
End 3 from layout line for center of arc	8*		4		...		12	

* Double penalty assessed for variation in dimensions and for errors which cannot be corrected.

Measurement	Penalty for Excess		Penalty for Shortage		Penalty for Variation		Credit	
	Maximum	Net	Maximum	Net	Maximum	Net	Maximum	Net
Edge 2 from layout line for center of arc	8*		4		...		12	
Chamfer line on surface 1 from end 3 . .	8*		4		8*		20	
Chamfer line on surface 1 from edge 2. .	8*		4		8*		20	
Chamfer line on end 3 from surface 1. . .	8*		4		8*		20	
Chamfer line on edge 2 from surface 1	8*		4		8*		20	
Angles formed by sides of dado and surface 1	4		8*		8*		20	
Angle formed by side of hole and surface 1	16		...		...		16	
Angle formed by curved edge and surface 1	4		8*		8*		20	
Angle formed by surface 1 and edge 5 . .	4		8*		8*		20	
Angle formed by surface 1 and end 4. . .	4		8*		8*		20	
Total points for compliance with measurements. . .							448	

II. Additional evidence of quality of work

Directions:

1. Inspect completed job carefully.
2. Rate the job with respect to each item listed below.
3. Record the appropriate figure to indicate your rating.

Item	Maximum Credit	Credit Earned
1. General appearance of work, expecially smoothness of surfaces 4, 5, and 6	10	
2. Extent to which layout lines are fine and distinct	10	
3. Extent to which stock is free from dents, splits, blemishes, and tool marks.	20	
4. Extent to which all angles are sharp and distinct	10	
Total points.	50	
Total points for quality of completed job . . .	498	

PERFORMANCE TEST

Operation of the IBM 083 Sorter

This is an example of a performance test for a widely used business machine. It illustrates the highly desirable procedure of listing step-by-step directions for preparing to give the test. This kind of directions makes it possible for a test to be more than a one-man activity. The individual test-writer/administrator may know how the equipment is to be prepared for examinees, but the procedures must be written in detail if others are to administer the test in the intended way.

Performance Test: Operation of IBM 083 Sorter*

NOTE: There are six possible versions or combinations of the job-required task of operating an 083 sorter. These six possible versions are alpha sorting, numeric sorting, card counting, block sorting, selection by sorting, and selection by rejection. The test illustrated in the following paragraphs examines performance of numeric sorting, card counting, and block sorting.

1. Directions for preparing for, and administering, the test.

a. Preparation for the test.

(1) Place a deck of 250 cards with punched information on each 083 sorter.

(2) Insure that the machine is on and warmed up.

(3) Depress all suppression keys.

(4) Set edit and edit stop and sort test switches in the ON position.

(5) Set the card count switch in the OFF position.

(6) Reset the card count indicator.

(7) Set sort selection switch in an erroneous position.

b. Administration of the test.

(1) Issue the student the "Directions to Students" (para 2 below).

(2) Direct the student to read the entire problem before beginning.

(3) Observe the student's performance. Record the student's performance on the scoring sheet (para 3 below). Score the

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*Example 13 from Regulation No. 350-100-1, Training: Systems Engineering of Training (Course Design). Fort Monroe, Virginia: Continental Army Command. 1968.

student's performance as he proceeds through the steps. If after a reasonable time the student is unable to proceed, score that step "NO," help the student only on that step, and allow the student to proceed.

(4) Insure that the student gives his card count orally at the end of the problem. If incorrect, score item 12 "NO." After completion of the test, determine the reason for the incorrect card count and correct the error.

2. Directions to students: 083 Sorter Test.

a. General instructions. This is a graded examination. All work in this examination must be your own. You are not authorized to communicate in any way with other students, give or receive assistance, refer to notes, make a record of your answers, or pass on information about the examination to other students. Any conduct contrary to the above will be the basis for appropriate disciplinary action.

b. Special instructions.

(1) The deck of cards placed on the machine is the deck you will work with on this problem.

(2) Insure that your machine is operating properly.

(3) If you think it is appropriate, you may accomplish more than one step in the same operation.

(4) Using the block sort method, sort the cards as follows

(a) Sort columns 26 through 28 numerically:

Column 28 minor.
Column 27 intermediate.
Column 26 major.

(b) Card count all cards.

(5) Upon completion of the operation outlined above, assemble your cards in proper order and return the entire deck to the instructor, informing him of your card count.

(6) Leave the machine on.

c. Material required. A deck of cards to be sorted will be supplied by the instructor.

d. Time limit. There is no time limitation. However, if you are not able to proceed after a reasonable time at any step of the operation, the instructor will assist you and you will be evaluated accordingly.

3. Directions for scoring 083 Sorter Test.

* * * * * * *

STUDENT NAME ______________________ STUDENT NUMBER ________________ DATE_____

1. Cards joggled before being placed in hopper. YES NO
2. Cards placed properly in hopper. YES NO
3. Suppression keys checked. YES NO
4. Sort test switch in SORT position. YES NO
5. Edit and edit stop switches in OFF position. YES NO
6. Sort selection switch set properly for each sort. YES NO
7. Sort brush set on proper column for blocking. YES NO
8. Sort brush set on proper column for minor sort. YES NO
9. Sort brush set on proper column for intermediate sort. YES NO
10. Cards removed properly from machine. YES NO
11. Sight check performed. YES NO
12. Card count made at beginning and end of operation. YES NO
13. All cards in correct sequence when returned to instructor. YES NO

Instructor ______________________

* * * * * * *

PERFORMANCE TEST

Fabrication of a Rigid Tubing Assembly

This test was devised as part of a U. S. Navy supported project to develop practical performance measures. The Institute for Research in Human Relations did the research and development.

The test illustrates the use of a relatively simple mock-up or simulator to provide a standardized, relatively simple test situation. This sort of simple simulator can be used effectively in performance tests for many occupations.

Note that the test works so that the examiner does not have to prepare the simulator for the next examinee, as the work requirement is to remove the tubing that is in place, and to fabricate and install a replacement.

Arthur Siegel and Douglas Courtney. *Development of Practical Performance Measures.* Institute Report No. 4, Volume 1. Philadelphia: Institute for Research in Human Relations, Series 1953.

HYDRAULICS

FABRICATION OF A RIGID TUBING ASSEMBLY

EXAMINEE INSTRUCTIONS

TASK This is a test of your ability to fabricate a rigid tubing assembly. Look at the "mock up" of a typical rigid tubing assembly which is in front of you. The tubing in the "mock up" is damaged and your task is to replace that tubing. Do the replacement exactly as you would ordinarily do it. That is, imagine that the damaged tubing is in a plane. In order to facilitate the scoring, first form the back piece bend (vertical leg) with fitting, (repeat) first form the vertical bend with fitting and then the horizontal bend and fitting. You may assume that the pressure in the system is zero.

SCORING You will be marked in the following areas:

1. The QUALITY of the finished product.
2. The PROCEDURE you follow in doing the job.
3. The MANNER in which you use your tools.
4. The SAFETY precautions you observe.
5. The TIME it takes you to complete the job.

However, the principal scoring emphasis is on doing the job well, so do not sacrifice doing a good job for speed.

TOOLS The following tools have been provided.

1. Tubing cutter
2. Hand tube bender
3. File
4. Mallet
5. Parker flaring tool
6. Pencil
7. Burring tool or pen knife

If you need additional tools, you may draw them.

MATERIAL Three (3) pieces 52 SO tubing, 18" long, .040 wall thickness.

HYDRAULICS

FABRICATION OF A RIGID TUBING ASSEMBLY

EXAMINER INSTRUCTIONS

TASK This is a test of the examinees' ability to fabricate a rigid tubing assembly.

GENERAL DIRECTIONS TO EXAMINER

1. Read very carefully and thoroughly the "Examinee Instructions". Be sure you understand the test and the method for administering it before attempting to give it to the examinee.

2. Assign the examinee to a work station and provide him with the "mock up", tools and material.

3. Have the examinee read the "Examinee Instructions" then read them to him out loud. Ask him if he has any questions. If he does not understand any part of his directions, re-read that part out loud to him until he understands what he is to do. If he does not understand the sequence in which the job is to be done, point to the vertical bend and say, "First make this bend and then (pointing to the horizontal bend) make this bend." Make sure that he understands what he is to do before he starts.

4. Have the examinee secure the work station when he is finished.

SCORING Carefully observe the examinee as he works. If you think that an examinee should receive credit on an item, do nothing to the number which appears after the observation called for on that item. If no credit is to be allowed on an item, encircle or X over the number which appears after that item. Give complete attention to the scoring. Do not (repeat), do not rely on your memory. Of course, the measurements of the final product will be made after the examinee has completed the job. The total score is the sum of the non-encircled or non-Xed credits. On completion of the scoring, add the non-encircled or non-Xed credits and enter the total in the space provided.

EXAMINER INSTRUCTIONS (Cont'd.)

TIME	Time is counted as soon as the examinee understands what he is to do and is told to start. Record the time that the examinee starts and finishes in the appropriate spaces. For credit on the time item, the examinee must finish in 23 minutes or less. Do not tell the examinee what the time allowance is. If the examinee does not finish in 23 minutes or less, allow him to finish. He receives no credit, however, on the time item unless he finishes in 23 minutes or less.

EXAMINER'S NOTE

File handle is to be removed from file and placed among tools before the examinee arrives.

HYDRAULICS

FABRICATION OF A RIGID TUBING ASSEMBLY

SCORING SHEET

NAME______________________________ RATE____________

SERVICE NUMBER____________________ DATE____________

Time Started___________________

TOOLS

1. Uses file for no work other than filing....... 1
2. Places handle on file prior to use............ 1
3. Refrains from horse play with mallet or other tools...................................... 1
4. Uses pencil to mark tubing.................. 1

PROCEDURE

5. Removes damaged tubing...................... 1
6. Inspects replacement tubing to see that it is free from surface defects.................... 1
7. Inspects replacement tubing to see that it is of required thickness........................ 1
8. Marks tubing at end of recess on back board fitting to get first bend..................... 1
9. Places tubing in hand tube bender, lines bend mark on tubing up with 45° mark on radius block and makes first bend.................. 1
10. Removes tube from hand tube bender, and marks tube at level with bottom of threads. Cuts tubing on pencil mark. (No credit unless mark made at level with bottom of threads)........ 1

SCORING SHEET (Cont'd.)

11. Deburrs both inside and out using burring tool or pen knife.................................. 1

12. Places standard fitting on tubing............ 1

13. Places tubing in flaring block, sets plunger in tubing and tightens vise. (No credit on this item if clamp tightened before flaring pin set).................................. 1

14. Taps plunger (No credit unless plunger rotated after each tap)......................... 1

15. Does not tap plunger after dull thud heard... 1

16. Removes from flaring block and secures standard fitting to back board fitting. Measures out from bottom fitting and makes 45° mark on tube.................................. 1

17. Places tubing in hand tube bender, lines up 45° mark and checks to see if bend is going in the right direction. (No credit unless check made) Makes bend..................... 1

18. Holds first flare against back board fitting, and makes pencil mark at bottom of threads at end of recess box fitting. (No credit unless mark made at level with bottom of threads)................................ 1

19. Cuts tubing on mark. Deburrs both inside and out................................ 1

20. Places triple type fitting on tubing. (No credit unless nut put on first, then sleeve with collar up on first attempt)........... 1

21. Places tubing in flaring block, sets plunger in tubing and tightens vise. (No credit on this item if clamp tightened before flaring pin set in tube)......................... 1

22. Taps plunger (No credit unless plunger rotated after each tap)..................... 1

SCORING SHEET (Cont'd.)

23. Does not tap plunger after dull thud heard.... 1

24. Removes from flaring block, places tubing in project box, hand tightens each fitting as far as possible. Finishes tightening with wrench. 1

25. Time at finish__________. Time to complete job______________. Time to complete job 23 minutes or less.............................. 3

QUALITY OF FINAL PRODUCT

26. One tube used to complete job.................. 3

27. Entire surface of tube and fittings completely free from scratches.......................... 3

28. Back board flare fits snugly into "go and no go"gage.................................... 3

29. Bottom flare fits snugly into "go and no go" gage.. 3

30. Back board flare completely free of burrs inside and out.. 3

31. Bottom flare completely free of burrs inside and out................... 3

32. Back board flare at least 80% of original thickness.................................. 3

33. Bottom flare at least 80% of original thickness 3

34. Back board flare square and concentric......... 3

35. Bottom flare square and concentric............. 3

36. Back board bend 90° (no tolerance)............. 3

37. Bottom bend 90° (no tolerance)............... 3

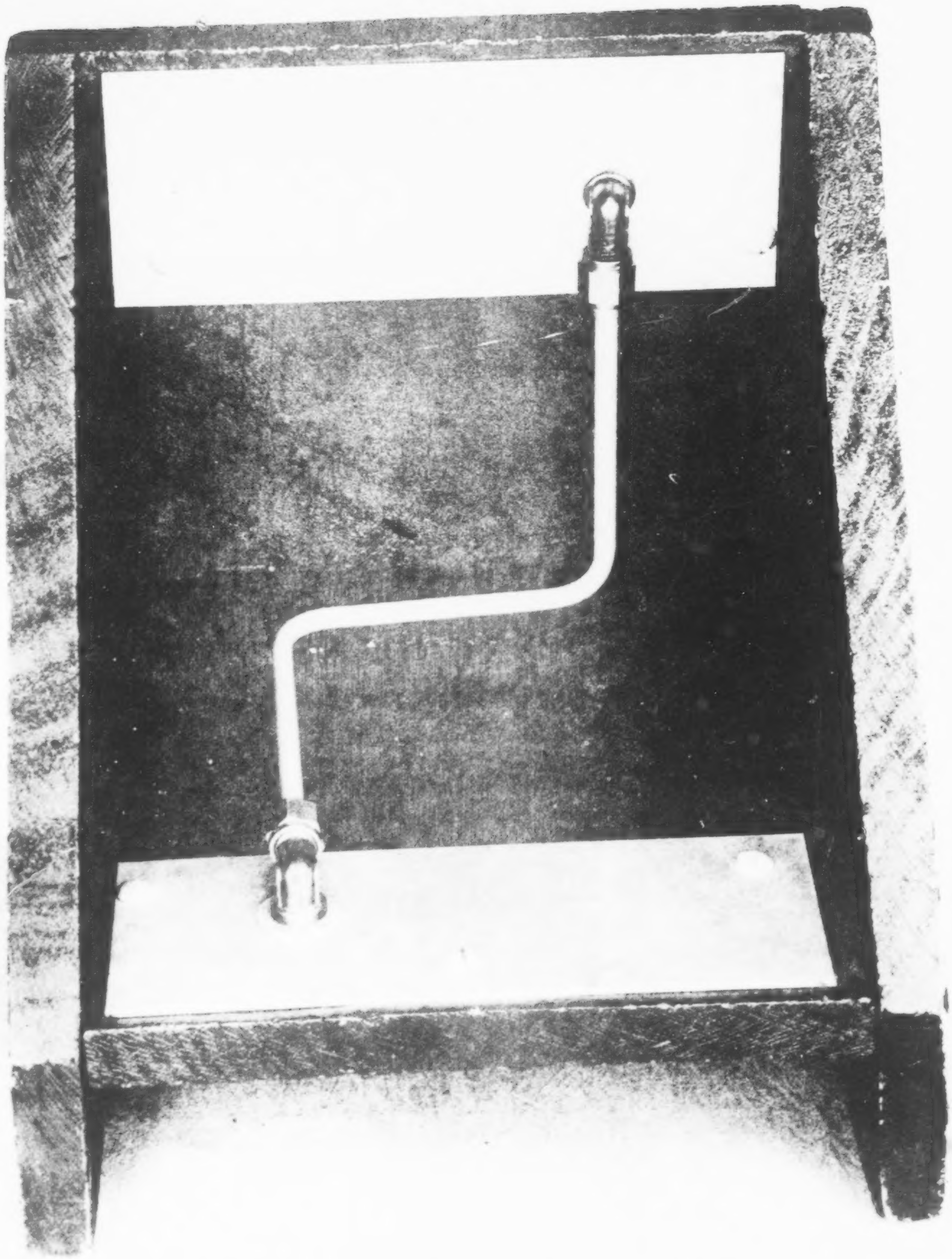
SCORING SHEET (Cont'd.)

38.	Neither flaring pock marked or chipped.....	3
39.	No filings, chips or other matter on inside of tube or fittings......................	3
40.	Back board bend neither kinked, flattened, or wrinkled................................	3
41.	Bottom bend neither kinked, flattened or wrinkled................................	3

Total Score________

FIGURE 27

MOCK-UP USED IN THE RIGID TUBING ASSEMBLY TEST



PERFORMANCE TEST

Fabrics Repair

This test was developed as part of a research project and represents good test-design practice. The task of repairing an L-shaped tear in fabric is part of the aircraft mechanic's job. The very simple simulator ("mock-up") which holds the fabric to be repaired is shown in Figures 28 and 29.

FABRICS

L-REPAIR

EXAMINEE INSTRUCTIONS

TASK This is a test of your ability to repair an L-type fabric damage. You are to sew and dope the damage exactly as you would ordinarily sew it. In front of you is a "mock up" of a typical L-type cut. That is the damage you are to repair. Be sure you understand what you are to do before you start.

SCORING You will be scored in the following areas:

1. The QUALITY of the finished product.
2. The PROCEDURE you follow in doing the job.
3. The MANNER in which you do the job.
4. The SAFETY precautions you observe.
5. The TIME it takes you to complete the job.

However, the principal emphasis is on doing the job well, so do not sacrifice doing a good job for speed.

TOOLS AND MATERIALS

You will be provided with the following:

1. Curved needle
2. Wax
3. Surface tape - 3 3/4" wide
4. Dope
5. Mock up
6. Thread
7. Cotton fabric

If you need additional tools, you may draw them.

FABRICS

L-REPAIR

EXAMINER INSTRUCTIONS

TASK This is a test of the examinee's ability to repair an L-type fabric damage.

GENERAL DIRECTIONS
TO EXAMINER

1. Read very carefully and thoroughly the "Examinee Instructions". Be sure you understand the test and method for scoring before giving it to the examinee.

2. Cut a piece of AN-CC-C-399 cotton fabric and fit it into the mock-up. In the center of the fabric make an L-shaped cut. Make each leg of the cut exactly 3" long.

3. Assign the examinee to a work station and provide him with the appropriate tools and materials.

4. Have the examinee read the "Examinee Instructions". Then re-read them to him out loud. Ask him if he has any questions. If there is anything he does not understand, re-read to him that part of the instructions which answers his question. Supply no accessory information. Remember, this is a test situation, not an instructional one. Make sure that the examinee fully understands what he is to do before he starts.

5. Have the examinee secure the work station when he is finished.

EXAMINER INSTRUCTIONS (Cont'd.)

SCORING Carefully observe the examinee as he works. If you think that the examinee should receive credit on an item, do nothing to the number which appears after the observation called for on that item. If no credit is to be allowed on an item, encircle or X over the number which appears after that item. Give complete attention to the scoring. Do not (repeat), do not rely on your memory. Of course, the measurements of the final product will be made after the examinee has completed the job. When the examinee has finished, write a figure 1 on one leg of the repair and write a figure 2 on the other leg. Then proceed with the measurements of the final product. The total score is the sum of the non-Xed or non-encircled figures. On completion of the scoring, add up the non-encircled or non-Xed figures and enter the total in the space provided.

TIME Time is counted as soon as the examinee understands what he is to do and is told to start. Record the time that the examinee starts and finishes in the appropriate spaces. For credit on the time item, the examinee must finish in 30 minutes or less. Do not tell the examinee what the time allowance is. If the examinee does not finish in 30 minutes, allow him to finish. He receives no credit, however, on the time item unless he finishes in 30 minutes or less.

FIGURE 28

MOCK-UP USED IN THE FABRIC REPAIR TEST

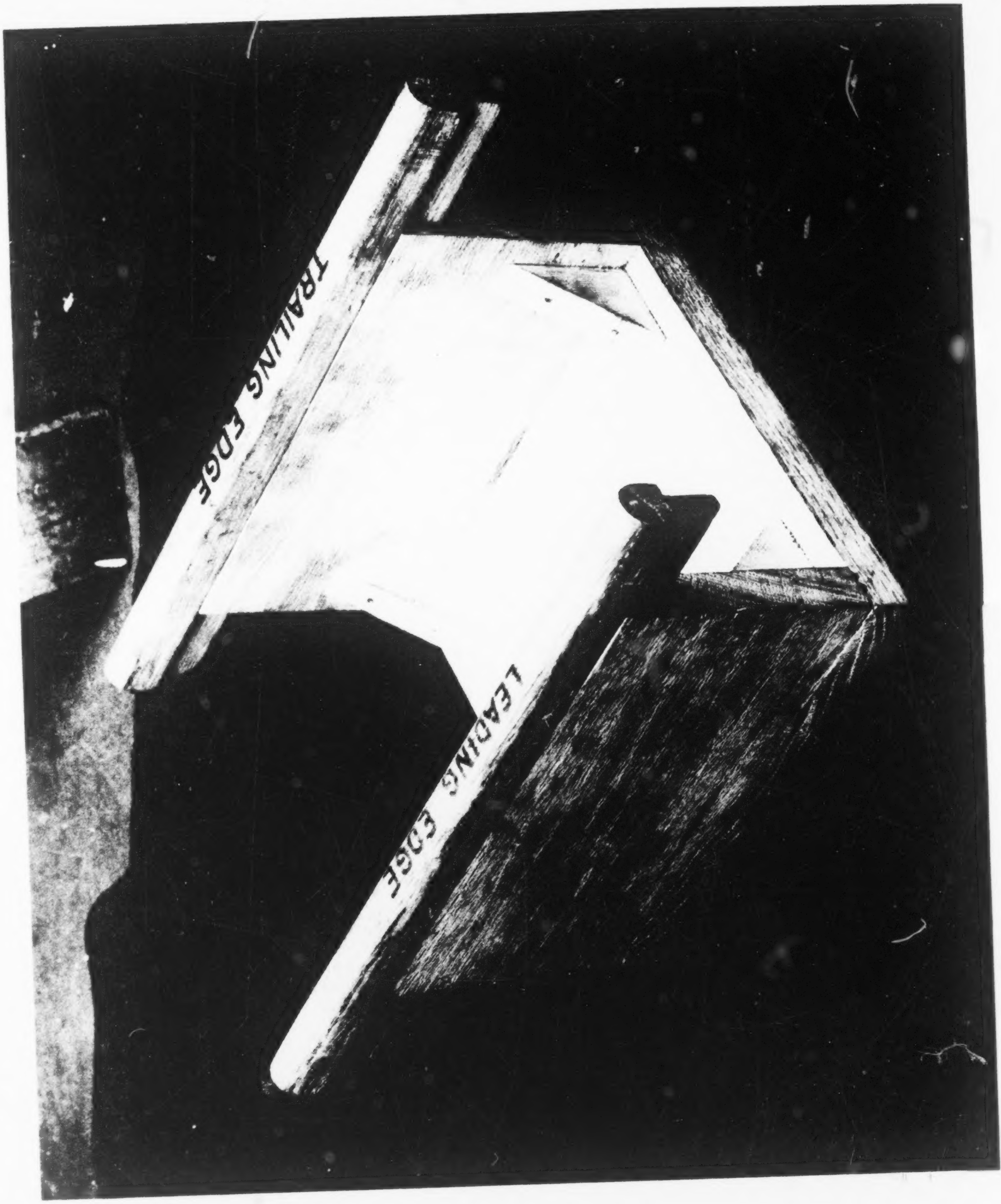
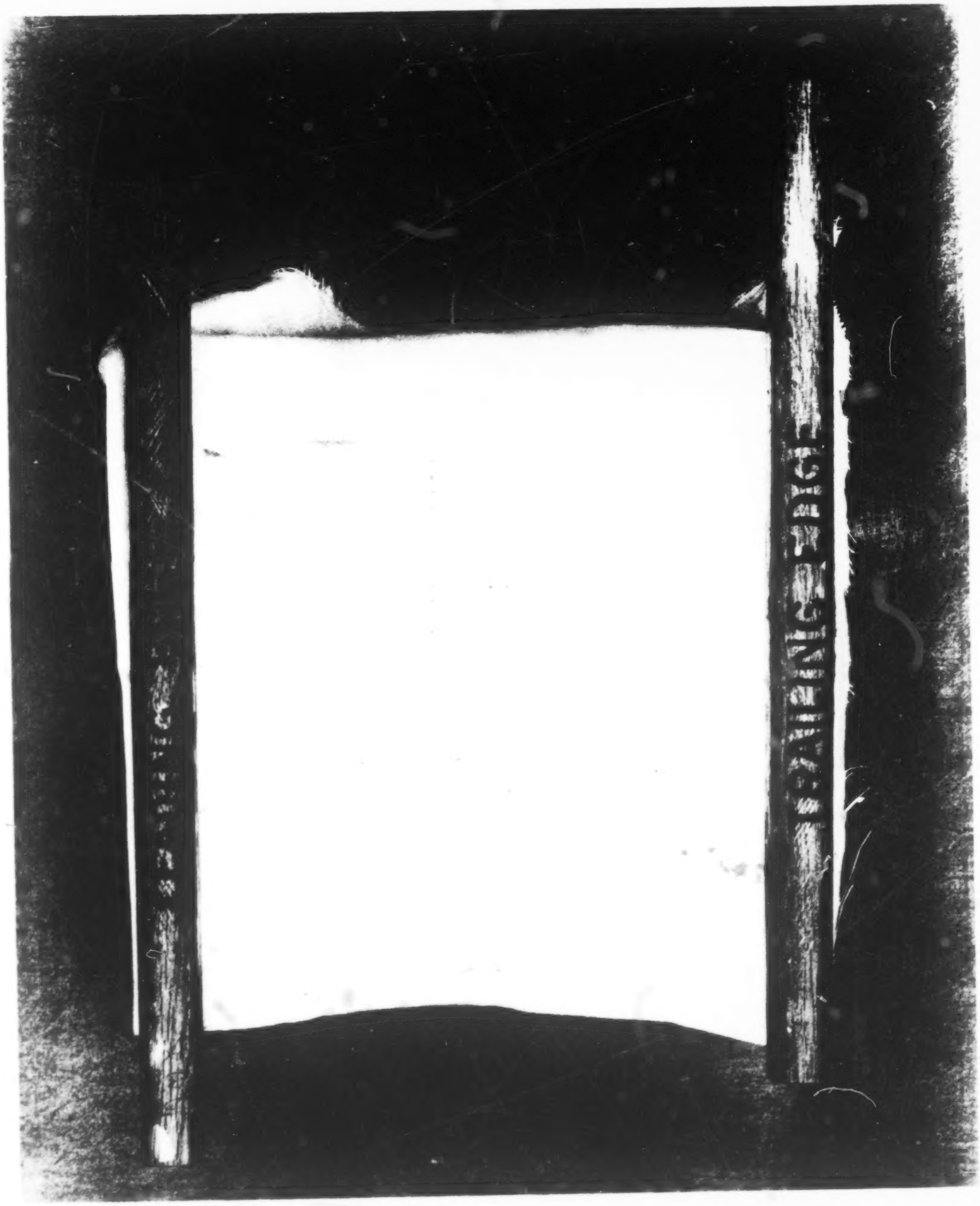

TRAILING EDGE
LEADING EDGE

FIGURE 29

MOCK-UP USED IN THE FABRIC REPAIR TEST
(WITH FABRIC INSERTED AND WORK COMPLETED)


TRAILING EDGE

AM PERFORMANCE EXAMINATION

FABRICS

L-REPAIR

SCORING SHEET

NAME____________________________ RATE_______________

SERVICE NUMBER__________________ DATE_______________

Time Started__________________

PROCEDURE

1. Tacks corner with single thread and ties square knot.................................... 1

2. Lays out stitch pattern........................ 1

3. Double threads needle and waxes thread......... 1

4. Ties proper slip knot, and sews up one leg, waxes thread every six stitches................ 1

5. Ties proper slip knot, and sews up other leg, waxes thread every six stitches................ 1

6. Secures thread at intersection................ 1

7. Applies first coat of dope (Allows 30 minutes drying).................................... 1

8. Cuts surface tape, dopes, applies surface tape, dopes over surface tape...................... 1

9. Time finished___________. Finished in 30 minutes or less. (Time finished is exclusive of drying time)................................ 3

SCORING SHEET (Cont'd.)

MEASUREMENTS OF THE FINAL PRODUCT

10.	NO loose pinked edges	3
11.	NO air bubbles under tape	3
12.	Correct edge distance on surface tape over leg No. 1	3
13.	Correct edge distance on surface tape over leg No. 2	3
14.	Spanwise tape applied first	3
15.	NO dope dropped through to opposite surface	3
16.	Minimum of 4 stitches per inch	3
17.	Completely correct edge distance for ALL sewing on leg No. 1	3
18.	Completely correct edge distance for ALL sewing on leg No. 2	3
19.	Correct baseball stitch on leg No. 1	3
20.	Correct baseball stitch on leg No. 2	3
21.	Hidden slip knot on leg No. 1	3
22.	Hidden slip knot on leg No. 2	3
23.	Thread at intersection secure with square knot	3
24.	NO stitches torn through fabric	3
25.	NO loose stitches	3

SAFETY

26.	Grounds work before doping	1
27.	Catches needle with finger when going through fabric	1
28.	No smoking while doping	1

Total Score__________

PERFORMANCE TEST

Joining Ferrous and Nonferrous Metals

(Welding Course)

Two documents for this test are shown: the Directions to Students and the Grade Sheet. While there is a relatively large number of check points, many of them call for subjective judgment on the part of the grader. However, note that the Grade Sheet calls for the "Instructor" to evaluate the process of performance, while a "Grader" evaluates the product. In the military service school which developed and uses this test, "Graders" are experienced, supervisory level instructors who specialize in product evaluation. Furthermore, "Graders" are provided with examples of satisfactory and unsatisfactory welds for reference.

PERFORMANCE TEST

Joining Ferrous and Nonferrous Metals

SUPPLEMENTAL TRAINING MATERIAL

Directions to Students

1. This is a GRADED test in which you will perform welding and brazing operations on ferrous and nonferrous metals in the flat and horizontal positions.
2. During this test you will be graded on the following:
   a. Preliminary steps (metal preparation, setup, flame adjustments, etc).
   b. Job procedure (welding technique, application of classroom principles, etc).
   c. Observance of safety rules.
   d. Quality of finished work.
3. You will have 3 hours to complete the test.

4. You will draw the following material, using DA Form 9-79, from the instructor:
   a. Four 4- by 1- by 1/2-inch cast iron coupons.
   b. Three 6- by 1- by 1/8-inch mild steel coupons.
   c. One 6- by 1- by 1/16-inch copper coupons.
   d. Two 2- by 1- by 1/16-inch copper coupons.
   e. One 1/4-inch cast iron welding rod.
   f. Four 1/8-inch brass or bronze rods.
   g. One piece of silver solder.
   h. Access to all fluxes.

5. Requirements.

   a. Weld an 80° corner joint on cast iron in the flat position.

   b. Braze an 80° corner joint on cast iron in the flat position.

   c. Braze a T-joint on mild steel in the horizontal position.

   d. Braze a copper-to-steel T-joint in the horizontal position.

   e. Silver solder a T-joint on copper in the horizontal position.

   f. Perform the above operations as directed by the instructor.

   g. You will be given NO instructional assistance during the test.

   h. When you have completed the assignment, close down your station, mark your roster number on the finished work, and turn it in to the instructor for grading.

Joining Ferrous and Nonferrous Metals

SUPPLEMENTAL TRAINING MATERIAL

Grade Sheet

Student's name______________Roster No______Class No_______Date______

Administrator_______________

1. INSTRUCTOR'S EVALUATION: Check "YES" or "NO" for each of the following items.

	YES	NO	CREDITS
a. Demonstrated knowledgeable ability in following directions?			
b. Properly assembled parts as outlined or directed by instructor?			
c. Correctly set welding current and/or pressures?			
d. Maintained correct electrode or torch angles?			
e. Possessed excellent coordination of mind and hands?			
f. Observed the desired safety factors - personal and equipment?			
g. Performed desired operator maintenance of equipment - care, etc?			

	YES	NO	CREDITS
h. Time consumed completing test: Mark "YES" for one statement only			
(1) Finished sooner than allotted time?			
(2) Finished within the allotted time?			
2. GRADER'S EVALUATION: Mark "YES" or "NO" for each of the following items:			
a. CAST IRON WELDING.			
(1) Good fusion?			
(2) Good penetration?			
(3) Bead uniform?			
(4) Free of undercut?			
(5) Free of overlap?			
(6) Free of checks or cracks?			
(7) Free of holes or voids?			
(8) Good crown on weld face?			
b, CAST IRON BRAZING.			
(1) Bead uniform?			
(2) Brass pulled much cast iron?			
(3) Evidence of good tinning?			
(4) Free of overlap?			

	YES	NO	CREDITS
(5) Free of any "burned" metal?			
(6) Free of runs over side?			
(7) Free of holes or voids?			
(8) Good crown on weld face?			
c. MILD STEEL BRAZING.			
(1) Bead uniform?			
(2) Evidence of good tinning?			
(3) Free of excessive "flowing"?			
(4) Free of any "burned" metal?			
(5) Free of holes or voids?			
(6) Good crown on weld face?			
d. DISSIMILAR METAL BRAZING.			
(1) Bead uniform?			
(2) Evidence of good tinning?			
(3) Free of excessive "flowing"?			
(4) Free of any "burned" metal?			
(5) Free of holes or voids?			
(6) Good crown on weld face?			

	YES	NO	CREDITS
e. SILVER SOLDERING.			
(1) Bead uniform?			
(2) Free of excessive "flowing"?			
(3) Evidence of good tinning?			
(4) Free of excessive warpage?			
(5) Free of wasted filler metal?			

INSTRUCTOR'S EVALUATION______

GRADER'S EVALUATION__________

TOTAL GRADE__________________

PERFORMANCE TEST

Metal Body Repair

This test is the end-of-course performance test for a body repair course of about 300 hours offered by a military service school. The purpose and scope of the course are stated as

> *Purpose:* To provide enlisted personnel with a working knowledge of the repair, painting, and installation of body components, radiators, and fuel tanks; and in inert gas welding, acetylene welding, and glassworking; and to modify other related items.
>
> *Scope:* Allied subjects such as heat treatment of metals, shop drawings, handtools, measuring tools, power tools, technical publications, and the Army equipment records system. Oxyacetylene welding and cutting, brazing, aluminum welding, and tungsten inert gas welding. Radiator and fuel tank repair, metal body repair operations, glassworking, and painting. Related subjects such as function of the service section, material readiness, and repair parts supply,...

The material shown includes an "Advance Sheet," which is given to examinees at least a day before the test is administered.

The instructions to students are very brief and do not include information on the time allowed and the grading procedures used. The Evaluation Checklist provides for instructor rating of performance during the work period and evaluation of the product by a "grader."

INSTRUCTIONAL UNIT: END-OF-COURSE PERFORMANCE TEST

Advance Sheet

Note. - Bring this advance sheet to class and use the study outline to study for this test.

THIS UNIT WILL TEST YOUR ABILITY TO PERFORM:

1. Measuring operations.
2. Operations using handtools.
3. Body repair operations.
4. Soldering applications.
5. Body plastics operations.
6. Glassworking operations.
7. Paint applications.
8. Stenciling operations.

HOMEWORK

Lesson, END-OF-COURSE PERFORMANCE TEST

Review: Use your notes and instructional materials to review the information taught throughout the entire course.

END-OF-COURSE PERFORMANCE TEST

STUDY OUTLINE

1. Handtools
2. Measuring tools
3. Soft soldering
4. Glassworking
5. Cutting and grinding safety glass
6. Metal body tools and equipment
7. Roughing and alining
8. Hammer finishing
9. Body file and pick hammer
10. Disk sanding
11. Paddle
12. Body repair with plastic
13. Body component
14. Paint tools and equipment
15. General preparation of surfaces
16. Paint application
17. Stencils

END-OF-COURSE PERFORMANCE TEST

SUPPLEMENTAL TRAINING MATERIAL

Directions to Students

1. Cut out lower left corner of panel (approximately 8-inch square) without damaging frame.
2. Cut a piece of metal to fit cutaway area.
3. Section (weld new piece on).
4. Sink weld.
5. Hammer finish.
6. Shrink stretched metal.
7. File and sand.
8. Prepare for plastic filler.
9. Apply filler.
10. File and sand filler.
11. Prepare panel for paint.
12. Prime and paint.
13. Stencil.

End-of-course Performance Test

SUPPLEMENTAL TRAINING MATERIAL

Evaluation Checksheet

STUDENT______________________________ROSTER NO__________________

CLASS NO__________________________

1. Instructor's evaluation. Check Yes or No for each of the following items.

	Yes	No	Credits
a. Housekeeping and police of area			
b. Initiative, effort, and use of time.			
c. Setup and operation of equipment.			
d. Ability to follow written or verbal directions.			
e. Attitude and interest toward this phase.			
f. Knowledge of correct tools and equipment for the job.			
g. Care of tools and equipment.			
h. Progress in technical know-how and skill in this area.			
i. Observation of safety precautions.			
j. Finished within allotted time.			
	Subtotal		

2. Grader's evaluation. Check Yes or No for each of the following items.

	Yes	No	Credits
a. Section laid out properly.			
b. Section fitted properly to panel.			
c. New section allows for expansion.			
d. Proper welding technique used to weld in a new section.			
e. Weld properly sunk.			
f. Correct hammer finishing technique used.			
g. Stretched metal shrunk properly.			
h. Properly filed and sanded.			
i. Plastic filler prepared and applied properly.			
j. Plastic filler filed and sanded properly.			
k. Panel prepared properly for painting.			
l. Primed and painted panel.			
m. Stenciled.			
n. Stencil centered.			
	Subtotal		
	Total		

PERFORMANCE TEST

Dental Hygiene

This is a comprehensive examination used in a military service school which trains enlisted dental specialists. The test is unusual in that it consists of three 4-hour segments, administered one a week over a three-week period. The documenetation is in the form of a lesson plan which combines some elements of the instructions to observer and of the instructions to students. A separate rating form is used for each weekly subtest. Two of the three are shown here. The breakdown of many of the tasks for grading is not given in as much detail as might be desirable.

Comprehensive Practical Examination (13 hours)

COURSES PRESENTED TO: Dental Specialist (Basic)

PLACE: Hygiene Clinic - Radiology Clinic

REFERENCES:

All previous references

STUDY ASSIGNMENT: Review classroom notes

TOOLS, EQUIPMENT, AND MATERIALS: Three SF 603's, three Dental Treatment sheets, and three Buck Slips per student, autoclaves, resuscitators, straight and angle handpieces, hand instruments and materials, and dental operatories (as required)

PERSONNEL: Nine primary instructors

TYPE OF INSTRUCTION: Examination

I. INTRODUCTION (5 min)

A. Opening Statement: The following 12 hours of practical examination conducted in 4-hour blocks in the fourth, fifth, and sixth weeks of the course will be the method used to determine the extent of the student's comprehension of the course of instruction. An additional one hour practical examination will be administered during the fourth week to determine the student's comprehension of the SF 603.

B. Objectives

1. Ability to prepare dental amalgam, silicate cement, root canal, and prophylaxis setups.
2. Ability to operate and perform maintenance on dental equipment.
3. Ability to expose and process dental X-rays.
4. Ability to maintain dental health records.
5. Ability to perform resuscitative procedures.

II. EXAMINATION (575 min)

A. Administrative Instructions

1. NCOIC -- schedules instructors for examination

2. Duties section leader

a. Students

(1) Divide students into groups

(2) First hour -- one group of students to X-ray section; the other half to Hygiene clinic

(3) Second hour -- switch student groups

b. Chairside examination

(1) Assign instructors

(2) Supervise activities

c. Sterilization and resuscitation examination

(1) Assign instructors

(2) Supervise activities

d. Maintenance examination

(1) Assign instructors

(2) Supervise activities

3. Radiography instructor

a. Give students instruction

b. Assign students to booths

c. Designate radiographs desired

d. Supervise student activities

B. Directions to Students

1. Remain seated in waiting area until called

2. No unnecessary talking during examination

3. Review notes until called

C. General Plan for Conducting Practical Examination

1. Examination will be in segments

2. Students individually perform tasks and duties as designated by instructor

a. Fourth week

(1) X-ray

(2) Operative setup (amalgam or silicate cement)

(3) Seating of patient

(4) Records

(5) Sterilization

(6) Maintenance

(7) Flossing

b. Fifth week

(1) X-ray

(2) Operative setup

(3) Seating of patient

(4) Routine surgical setup

(5) Records

(6) Sterilization

(7) Maintenance

c. Sixth week

(1) X-ray

(2) Operative setup

- (3) Impaction surgical setup
- (4) Records
- (5) Resuscitation
- (6) Maintenance

3. Instructors direct student activities
   - a. Assign duties
   - b. Act as patient (when necessary)
   - c. Grade student performance

III. CRITIQUE (5 min)

- A. Questions From Students
- B. Fourth Week -- Duties, Science and Records, Radiology
- C. Fifth Week -- Duties, Science and Records, Radiology
- D. Sixth Week -- Duties, Science and Records, Radiology

NOTE: Duties critique is conducted during the examination.

- E. Closing Statement: The purpose of these practical examinations has been to observe your performance on the job, to enable you to avoid practical mistakes, and to have you profit by those mistakes that you may have made.

STUDENT NAME ____________________

5th Week Comprehensive Practical Examination

A. **OPERATIVE SETUPS** (10 min)

1. Basic Exam Setup......... 2 ____
2. Anesthetic Setup......... 4 ____
3. Instrument Selection.....19 ____

☐ Total Errors

B. **SURGICAL SETUP** (10 min)

1. Basic Exam Setup......... 3 ____
2. Anesthetic Setup..........4 ____
3. Instrument Selection......8 ____
4. Sterile Technique.........5 ____

☐ Total Errors

C. **SEATING OF PATIENT** (10 min)

1. Unit Preparation..........2 ____
2. Chair Preparation.........1 ____
3. Calling Patient...........1 ____
4. Chair Adjustment..........2 ____
5. Removal of Glasses
   and Appliances..........1 ____
6. Light Adjustment..........2 ____
7. Washing of Hands..........1 ____
8. Draping Patient...........1 ____
9. Placing Basic Setup and
   Saliva Ejector..........3 ____
10. Wiping Syringes...........4 ____
11. Repeating Instructions....1 ____
12. Dismissing Patient........1 ____

☐ Total Errors

D. **STERILIZATION** (5 min)

Point Value....................5 ____

☐ Total Errors

Instructor____________________Date________

E. **MAINTENANCE** (10 min)

Point Value...................10 ____

☐ Total Errors

F. **RADIOGRAPHY** (20 min)

Point Value...................15 ____

☐ Total Errors

G. **RECORDS** (15 min)

Point Value...................15 ____

☐ Total Errors

H. **ATTRIBUTES**

1. Attitude................. 5 ____
2. Personal Appearance......10 ____
   (Section Leader only)

☐ Total Errors

COMMENTS:

Total Points.......................... 125
Errors.......... ____

FINAL GRADE..... ____

STUDENT NAME ______________________________

6th Week Comprehensive Practical Examination

A. **OPERATIVE SETUP** (10 min)

1. Basic Exam Setup..........4 ___
2. Instrument Selection.....36 ___

☐ Total Errors

B. **SURGICAL SETUP** (15 min)

1. Basic Exam Setup..........4 ___
2. Anesthetic Setup..........4 ___
3. Instrument Selection.....28 ___
4. Aspirator.................2 ___
5. Sterile Technique.........2 ___

☐ Total Errors

C. **RESUSCITATION** (10 min)

1. Operation of Resuscitator 5 ___
2. General Knowledge........ 5 ___

☐ Total Errors

D. **MAINTENANCE** (10 min)

Point Value..................10 ___

☐ Total Errors

Instructor__________________ Date__________

E. **RADIOGRAPHY** (20 min)

Point Value................ 20 ___

☐ Total Errors

F. **RECORDS** (10 min)

Point Value................ 15 ___

☐ Total Errors

G. **ATTRIBUTES**

1. Attitude................. 5 ___
2. Personal Appearance......10 ___

☐ Total Errors

COMMENTS:

Total Points.......................... 150
Errors.......... ___

FINAL GRADE..... ___

PERFORMANCE TEST

Offset Press Operation

An example of a variation in the usual rating sheet format is shown here. This rating form really involves three documents. First is the individual student "Practical Exercise Grading Sheet," which includes a breakdown of procedural objectives under the heading "Preparation of Press" and of product evaluation elements under the heading "Quality of Job." The second document is the "Instructor Cut Sheet" which lists penalty points for each objective listed on the Grading Sheet. The third document is a list of press technique and safety violations which are commonly scored in all tests in the course. These violations are scored in the last two items on the Grading Sheet.

PRACTICAL EXERCISE GRADING SHEET

NAME

ROSTER NR.

START TIME

FINISH TIME

GRADER

DATE

GRADE

MANNER OF PERFORMANCE FOR JOB EVALUATION T.440-115

OBJECTIVES (DP) PREPARATION OF PRESS	WTS.	PEN.	CRS.
1. Preparations of plate clamps	7		
2. Mounting plate correctly (position)	4		
3. Position of stock	6		
4. Adjustment of airblast and suction	5		
5. Setting of pile Height Governor	4		
6. Setting of two Sheet choke	7		
7. Setting of pull-in wheels	4		
8. Adjustment of the head stop bar	5		
9. Proper push for side guide	5		
10. Setting of Drop Bar	4		
11. Proper setting of Register wheels	5		
12. Setting of Delivery Jogger Blades	4		
13. Setting of Ink Fountain Keys	6		
14. Care of Plate during and after running job	4		
15. Adjustment of Ink Rollers	5		
16. Adjustment of Dampener Rollers	5		
QUALITY OF JOB			
1. Image Fidelity: Scratches, finger prints, and low spots	14		
2. Water	14		
3. Ink	14		
4. Register	18		
5. Correct registration marks	10		
6. Excess wastage			
7. Observance of Safety Regulations Number of violations /1/2/3/4/5/6/ X 5 pts each			
8. Press techniques Number of violations /1/2/3/4/5/6/ X 2 pts each			
REMARKS:			
TOTAL	150		

WORK SHEET

PRACTICAL EXERCISE TEST
JOB EVALUATION
INSTRUCTORS CUT SHEET

Preparation of Press

1. Yes or No
2. Yes or No
3. Poorly jogged pile: Minus 2
   Tail weights set wrong: Minus 1
   Corner brackets set wrong: Minus 1
   Pile guide bars set wrong: Minus 1
   Stock not centered: Minus 1
4. Yes or No
5. Pile not at proper height: Minus 2
   Governor not set when at lowest position: Minus 1
   Not set approx 2 inches from tail edge: Minus 1.
6. Yes or No
7. Yes or No
8. Not centered: Minus 2
   Not paralleled: Minus 3
9. Yes or No
10. Too high: Minus 2
    Too low: Minus 2
11. Yes or No
12. Yes or No
13. Not even from side to side: Minus 4
    Blade not fully seated: Minus 2
14. Scratched, dented or torn: Minus 2
    Failed to clean, gum and straighten: Minus 2
15. Yes or No
16. Yes or No

Quality of Job

Items 1, 2, 3, and 4 use chart A

CHART A

Percentage of bad sheets	Degree of imperfection Slight	Moderate	High
0 to 20%	2	2	4
20 to 40%	4	5	6
40 to 60%	7	8	9
60 to 80%	10	11	12
80 to 100%	12	13	14

Overtime - 1 pt per ea 5 min up to 1/2 hour

5. Yes or No

6. Use chart B

CHART B

Chart B - Penalty for excess waste

Sheets wasted in excess of allotted 50 for each color	Points
20 to 40 sheets	2
40 to 80 sheets	4
80 to 100 sheets	8
100 to 120 sheets	12
120 to 140 sheets	16
140 to 150 sheets	20
150 to 200 sheets	25
200 to 250 sheets	30
250 to 300 sheets	35
300 to 350 sheets	40
350 to 400 sheets	45
400 to 450 sheets	50

7. Observance of Safety Regulations

   Subtract 5 points each

8. Press Techniques

   Subtract 2 points each

------PRESS TECHNIQUE------

Following is a list of violations of good Offset Press Operation. Two (2) points will be subtracted for each violation during graded exercises.

a. Mishandling of plate before mounting.
b. Mounting or removing plate with guard on.
c. Removing blanket without first releasing tension.
d. Improper gumming of plate.
e. Failure to keep plate wet during stop downs.
f. Failure to place dampening rollers in #1 position before dropping ink rollers.
g. Failure to give plate time enough to get wet before dropping ink rollers.
h. Removing wrong end of plate from press first.
i. Failure to wash blanket and back cylinder after gumming.
j. Failure to wash blanket when leaving press for long period of time.
k. Failure to wash bearers and cylinders after removing plate and blanket.
l. Failure to check sheets while running job.
m. Using wrong side guide.
n. Suckers hitting the sheet guards on the conveyor board.
o. Oil holes in roller bearing facing down.
p. Vibrator blocks not riding properly.
q. Leaving dampening rollers in #1 position when press is stopped.
r. Putting press on impression at wrong time.
s. Improper care of dampening rollers.
t. Improper press maintenance.
u. Printing more than 3 sheets at a time during make-ready.
v. Other violations.

------SAFETY------

Following is a list of safety violations. Five (5) points subtracted for each violation during graded exercises.

a. Improper use of rags or tools on press.
b. Making adjustments on press while press is in motion.
c. Jogging or running press with guards removed.
d. Trash or liquid on floor around press.
e. Removing or replacing any part of the press while press is in motion.
f. Failure to lock or secure any roller or part of the press that might come out.
g. Failure to have safe switch on when working on press.
h. Wearing rings, watches or chains while working on press.
i. Wearing of loose clothing, sleeves down, etc.

PERFORMANCE TEST

Machinist

The two tests which follow offer some interesting similarities and differences. Both cover the production of a steel object, given a drawing, raw material, and the necessary machine tools.

The first test emerged in a research study in 1954. The second test was put into use at a military service school in 1969. The research test gave the examinees the sequence of operations; the school test requires the examinee to plan and record, in advance, the sequence of operations he will follow. Both tests are scored on the quality of the product, with detailed tolerances being specified for each measurement. The research test object was also rated on the quality of "workmanship" or finish.

Machinist Test (Research Project)

Information for the Work Sample

The piece specified on the drawing that is attached to the cover page is to be produced to the best of your ability. The time that is to be entered on the bottom of the drawing is not too important and only the processing time is to be recorded.

The finished product will be forwarded to the Human Resources Research Center[1] where it will be ranked according to exactness and finish.

Following are a few things to bear in mind before and during the production of this piece.

1. Only one piece of material will be used.
2. It is advisable to start with newly sharpened tools.
3. Choose your equipment (machinery) accordingly.
4. Record actual processing time only.
5. Please coat all samples with a film of light oil.
6. Stamp the same number on the piece that's on the blue print which will be your Identification Number. We are not interested in names.
7. **Please roll your product in your drawing and fasten securely before turning it in to your supervisor.**

Sequence of Operation

Lathe Work

1. Select 1 3/8 in. diameter low carbon steel stock.
2. Prepare work for turning between center.
3. Mount work between centers and turn .6875 diameter to square shoulder as per drawing.
4. Chamfer 45° by 1/16 in.
5. Make 1/34 by 1/32 in. radius.
6. Turn work end for end between centers.
7. Turn 7/8 in. diameter to required length and form 3/16 in. radius.
8. Turn threaded diameter to proper length.
9. Locate and undercut 3/32 in. radius to proper diameter.
10. Turn 1/8 in. radius at shoulder.
11. Machine acme thread.
12. Chamfer end of thread as per drawing.
13. Set up taper attachment.
14. Machine taper to specifications.

---

[1] HRRC has subsequently been integrated into the Air Force Personnel and Training Research Center.

Mill Work

1. Mount index head centers on milling machine.
2. Mount work between centers.
3. Select and set up side milling cutter.
4. Mill flats to correct width.

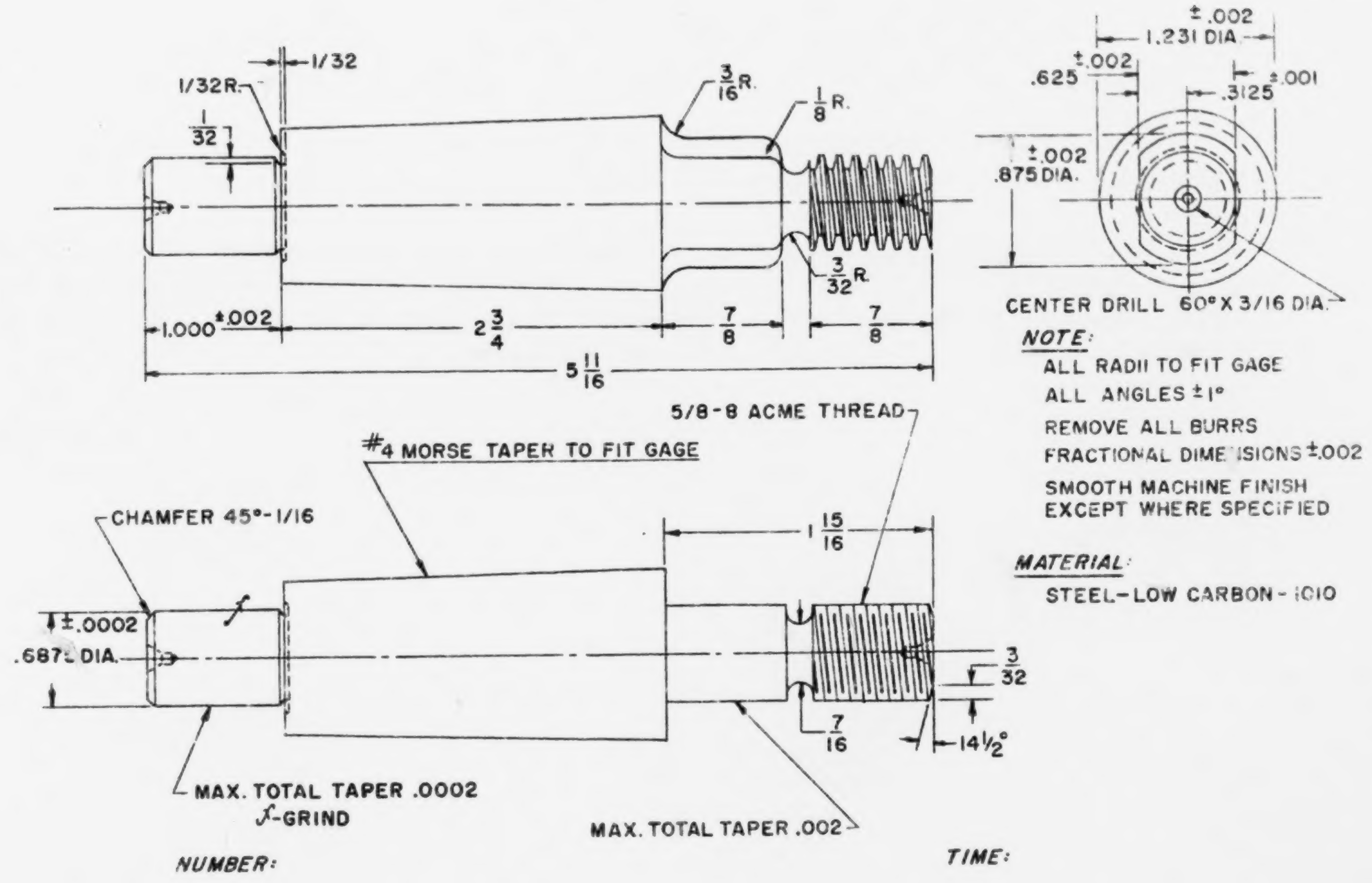

1/32
1/32R.
1/32
3/16 R.
1/8 R.
3/32 R.
1.000 ±.002
2 3/4
7/8
7/8
5 11/16
±.002
1.231 DIA.
±.002
.625
.3125 ±.001
±.002
.875 DIA.
CENTER DRILL 60° X 3/16 DIA.
NOTE:
ALL RADII TO FIT GAGE
ALL ANGLES ±1°
REMOVE ALL BURRS
FRACTIONAL DIMENSIONS ±.002
SMOOTH MACHINE FINISH
EXCEPT WHERE SPECIFIED
MATERIAL:
STEEL-LOW CARBON-1010
5/8-8 ACME THREAD
#4 MORSE TAPER TO FIT GAGE
CHAMFER 45°-1/16
1 15/16
±.0002
.6875 DIA.
3/32
7/16
14½°
MAX. TOTAL TAPER .0002
ƒ-GRIND
MAX. TOTAL TAPER .002
NUMBER:
TIME:

Fig. 1. Blueprint drawing of the machined product for the work-sample test.

Instructions to Raters of Work Samples

1. The work samples are to be rated on two main points: Accuracy and Workmanship. A 5-point scale will be used in rating the work samples and is as follows:

(5) Superior
(4) Excellent
(3) Satisfactory
(2) Unsatisfactory
(1) Not Usable

2. Accuracy. The work samples are to be graded according to the ability of the machinist to follow the instructions and blueprint and on the accuracy of the machining operation. Using the proper measuring tools, refer to the blueprint and measure the sample as required by the rating form. If the machining operation is "Within Tolerance," the rating given should be Superior 5. Check Box 5 opposite item measured on rating form. If the machining operation is "Out of Tolerance," the rating given should be Not Usable 1. Check Box 1 opposite item measured on rating form.

Accuracy will be rated on only two points. Give a 5 for work within tolerance. Work not in tolerance should be given a 1.

3. Workmanship. Here the work samples are to be rated on the ability of the machinist to "finish" his work properly. The rater grades the work sample on the appearance of the work at that particular step. Ratings from 5 (Superior) to 1 (Not Usable) should be given.

RATING SHEET FOR WORK-SAMPLE TEST

ACCURACY 1 .5 WORKMANSHIP 1 2 3 4 5

Item 1. Facing to length.
 a. Length ± .002

Item 2. Taper.
 a. Taper to fit gage
 b. Dia. ± .001, ± .002 (two ends)
 c. Roundness, actual value, 1/3 rd & 2/3 rds

Item 3. Radii.
 a. Convex
  1. Size
 b. Concave
  1. Size

Item 4. Ground Diameter.
 a. Dia. ± .0002
 b. Length, ± .002

Item 5. Flats.
 a. Distance across Flats ± .002
 b. Length of Flat ± .002

Item 6. 7/8" Diameter.
 a. Diameter, ± .002
 b. Length, ± .002

Item 7. Chamfer.
 a. Angle, ± 1°
 b. Length, ± .002

Item 8. Thread.
 a. O.D. Thread Dia., ± .000, - .006
 b. Length, ± .002
 c. Pitch Dia., Max .5625, Min., .5495

Item 9. Undercut at end of thread.
 a. Width; to fit gage.
 b. Diameter, ± .002
 c. Radius; to fit gage.

SUPPLEMENTAL TRAINING MATERIAL

Solution to Performance Test

1. INTRODUCTION. The following is one acceptable solution for fabricating the ball peen hammer. It is NOT the only acceptable solution.

2. LIST OF MATERIAL.

   a. Steel, SAE 1020 - 3/4 inch by 11 inches.

   b. Steel, SAE W1-10 - 1-1/4 inch by 3-1/4 inches.

   c. Steel, SAE wl-10 - 0.880 inch by 4 inches.

3. TOOLS AND EQUIPMENT.

Note. - The following are in addition to tools and equipment listed in the lesson plan.

   a. Lathe, complete.

   b. V-center.

   c. Drills - 5/16 inch, 29/64 inch, U-drill.

   d. 5/8-inch counterbore.

   e. 1-1/2 inch end mill.

   f. Taps - 7/16-14 UNC, 1/2-20 UNF.

   g. Micrometer; screw thread 14- to 20-pitch.

   h. Dial indicator.

   i. Radius gage.

4. PROCEDURE.

   a. Handle and screw plug.

      (1) Check and debur stock.

(2) Mount in collet and face and center-drill both ends.

Note. - Do not face to length.

(3) Mount between collet and center.

(4) Turn 5/8-inch diameter approximately 3 inches long.

(5) Mount between 5/8-inch collet and center.

(6) Undercut for knurl approximately 6 inches.

(7) Knurl.

(8) Turn 1/2-inch diameter 3/4 inch long.

(9) Reverse stock and turn 7/16-inch diameter 3/4 inch long.

(10) Turn 0.355-inch undercut.

(11) Reverse stock; turn 0.440-inch undercut.

(12) Cut and chamfer 1/2-20 UNF thread.

(13) Reverse stock; cut and chamfer 7/16-14 UNC thread.

(14) Face center hole out of plug end and part to length.

(15) Offset taper attachment and cut taper.

(16) Mount versa-mill and mill 1/2-inch hexagon and 0.489-inch flat.

(17) Face out center hole from threaded end.

(18) Face to length.

(19) Drill and tap hole.

(20) Assemble plug in handle and cut two 1/16-inch radii and machine 1/16-inch crown.

b. Ball peen head.

(1) Check and debur stock.

(2) Mount in collet.

(3) Turn 1-inch diameter approximately 1-1/2 inches long.

(4) Reverse stock and turn remaining stock to 1-inch diameter.

(5) Mount in V-pad.

(6) Center-drill, drill, counterbore, and tap.

(7) Mount in collet.

(8) 3/16-inch radius - cut two.

(9) Turn 0.875-inch and 0.940-inch diameters.

(10) Turn 7/16-inch radius.

(11) Reverse stock and face to length.

(12) Turn 1/16-inch crown.

c. Cross peen head.

(1) Check and debur stock.

(2) Mount in 4-jaw chuck.

(3) Drill and tap.

(4) Turn 13/64-inch chamfer 1-1/8 inch long by offsetting compound rest.

(5) Mount versa-mill and machine angles.

(6) Face to length.

d. Debur and polish handle and both heads.

(1) Heat-treat heads.

(2) Repolish heads.

(3) Assemble handle to ball peen head.

(4) Stamp and turn in for grading.

FIGURE 31
MACHINE DRAWING FOR A WORK SAMPLE TEST
FOR MACHINISTS (SCHOOL TEST)

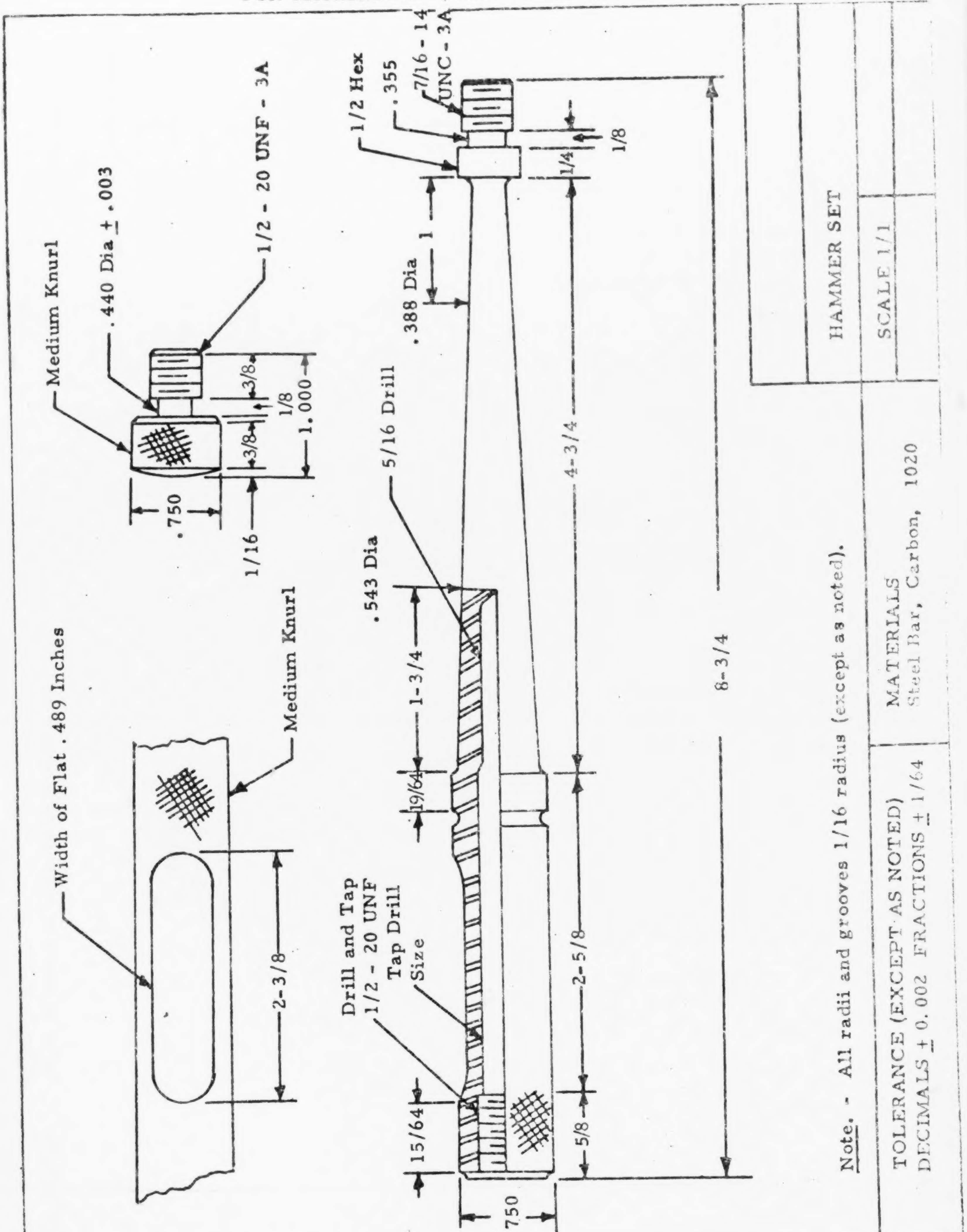
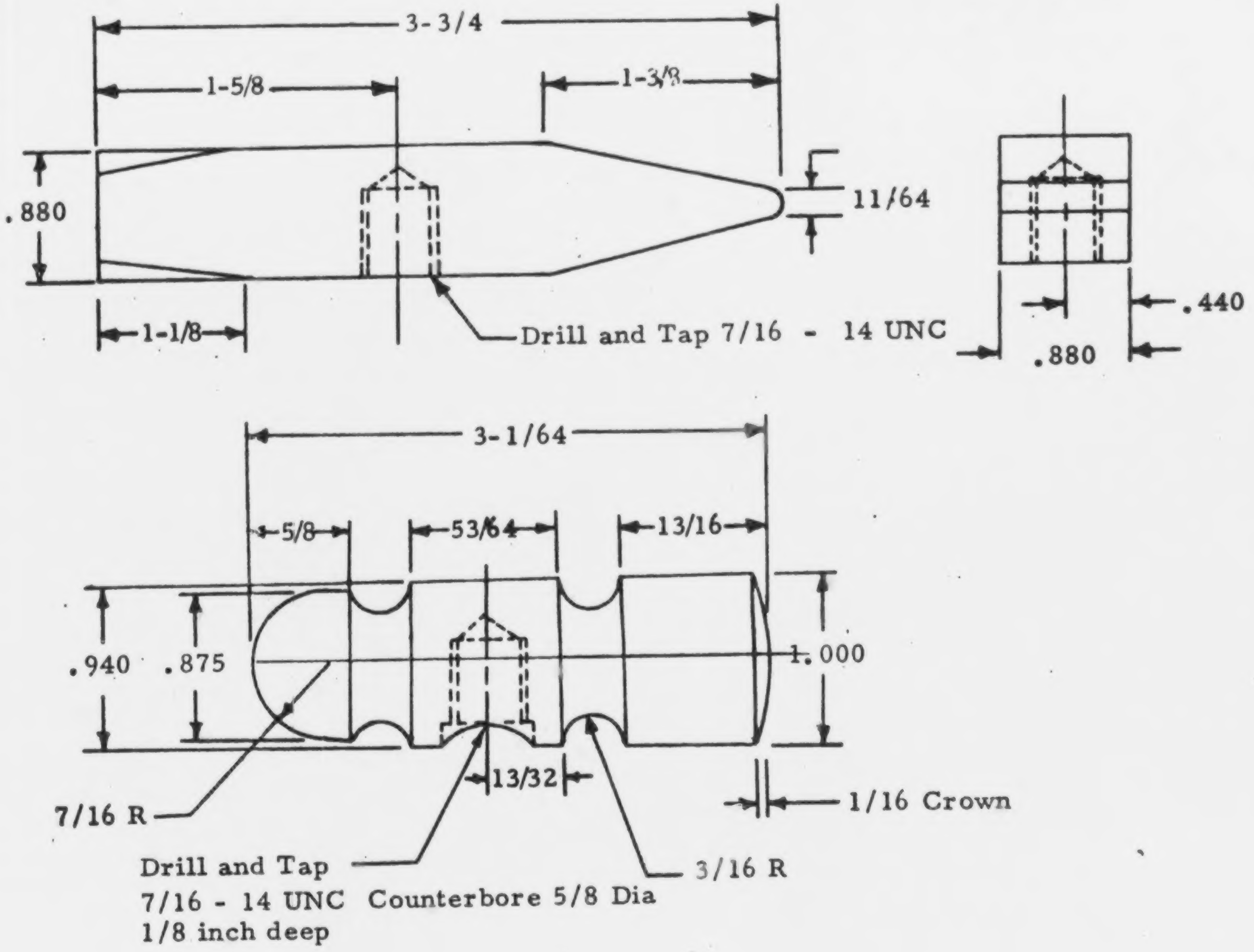

Width of Flat .489 Inches
Medium Knurl
2-3/8
Medium Knurl
.440 Dia ± .003
1/2 - 20 UNF - 3A
.750
1/16
3/8
1/8
3/8
1.000
1/2 Hex
.355
7/16 - 14 UNC - 3A
1/8
1/4
1
.388 Dia
5/16 Drill
.543 Dia
1-3/4
19/64
Drill and Tap 1/2 - 20 UNF Tap Drill Size
15/64
.750
4-3/4
2-5/8
5/8
8-3/4
HAMMER SET
SCALE 1/1
Note. - All radii and grooves 1/16 radius (except as noted).
MATERIALS
Steel Bar, Carbon, 1020
TOLERANCE (EXCEPT AS NOTED)
DECIMALS ± 0.002 FRACTIONS ± 1/64

FIGURE 31 (continued)


3-3/4
1-5/8
1-3/8
.880
11/64
1-1/8
Drill and Tap 7/16 - 14 UNC
.440
.880
3-1/64
5/8
53/64
13/16
.940
.875
1.000
13/32
1/16 Crown
7/16 R
Drill and Tap
7/16 - 14 UNC
1/8 inch deep
Counterbore 5/8 Dia
3/16 R

Note. - Width of chamfer on square hammer head to be 13/64 inches at the face.

TOLERANCE (EXCEPT AS NOTED)
DECIMALS ± 0.002 FRACTIONS ± 1/64

MATERIALS:
TOOL STEEL, CARBON
GRADE C, CLASS W1-10

HAMMER SET

SCALE 1/1

Hammer Set Grade Sheet

Note. - The following dimensions have been checked to the tolerances shown.

DIMENSION TO BE CHECKED	DIMENSION	TOLERANCE	POINTS OF
Handle			
1. Overall length	8-3/4 in	±1/64 in	
2. Length of taper and radius	4-3/4 in	±1/64 in	
3. Diameter of taper 1 inch from 0.500-in hex	0.388 in	±0.002 in	
4. Diameter of taper 2 inches up from 0.388-inch diameter	0.543 in	+0.002 in	
5. Dimension across flats of hex	1/2 in	±1/64 in	
6. Major diameter 7/16 - 14 UHC-3A	7/16 in	0.438 max 0.428 min	
Cap			
7. Length	1.000 in	±0.002 in	
8. Major diameter 1/2 - 20 UNF-3A	1/2 in	0.500 max 0.492 min	
Head Ball Peen			
9. Length	3-1/64	±1/64 in	
10. Center diameter	0.940 in	±0.002 in	
11. Radius	7/16 in		

DIMENSION TO BE CHECKED	DIMENSION	TOLERANCE	POINTS OFF
Head Cross Peen			
12. Length	3-3/4 in	± 1/64 in	
13. Length of cross peen	1-3/8 in	±1/64 in	
14. Radius of cross peen	11/64 in		
15. Overall appearance of hammer set			

Assembly - take five points off total grade if project does not go together.

STUDENT'S GRADE ________________

STUDENT'S NAME ________________

CLASS NUMBER ________________

Disposal - student may keep project for his own use.

INSTRUCTOR'S REMARKS AND INITIALS

JOB PLANNING SHEET

Lathe Performance Test

JOB: ____________________

STUDENT'S NAME: ____________________

CLASS NO: ____________________

DATE: ____________________ TIME: ____________________

LIST OF MATERIALS

1.
2.
3.
4.

TOOLS AND EQUIPMENT

1. Student toolbox.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.

PROCEDURE

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

13.

14.

15.

16.

17.

18.

19.

20.

21.

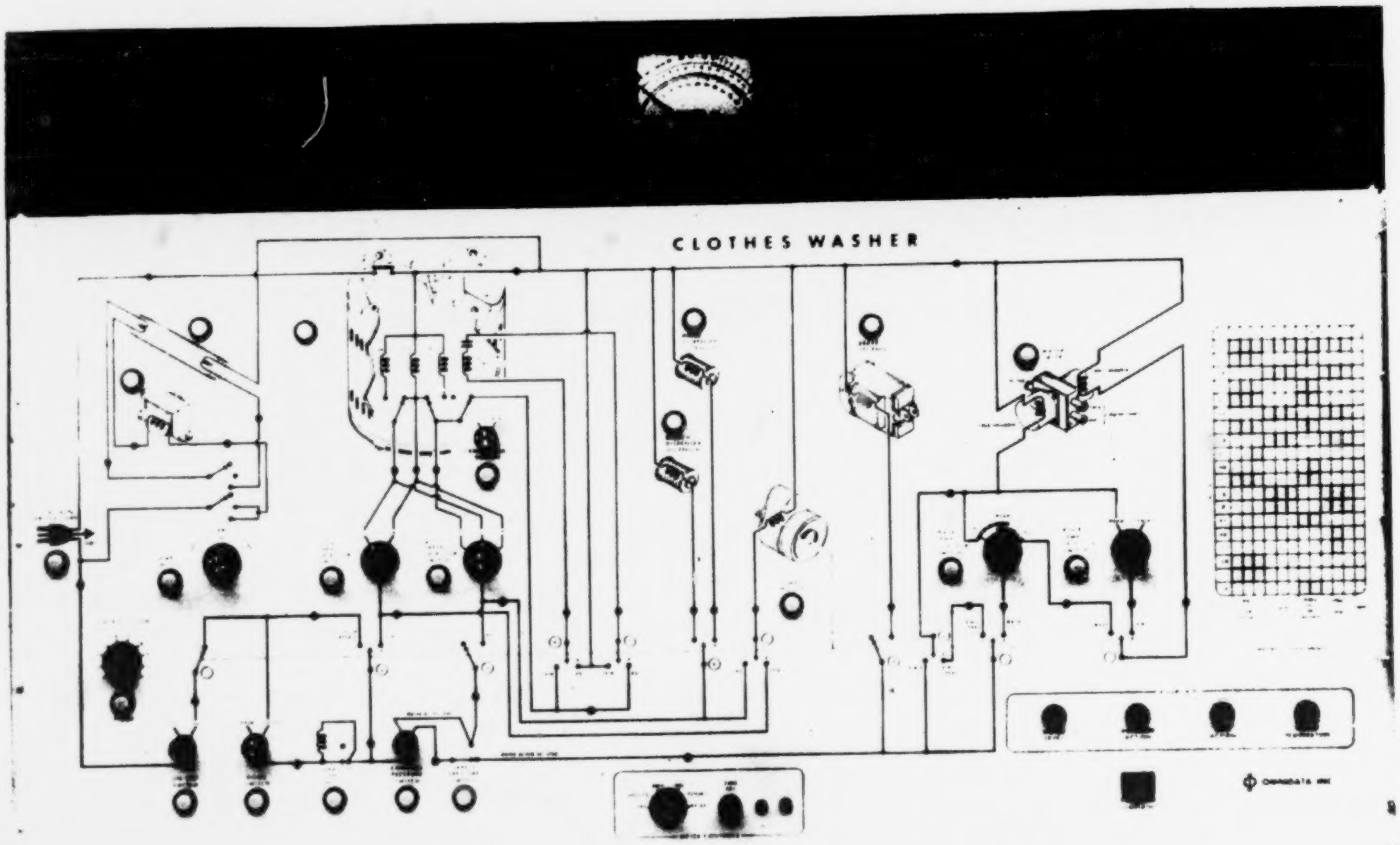
PERFORMANCE TEST

Automatic Clothes Washer Simulator

Omnidata, Inc.,Beverly, New Jersey

FIGURE 32

AUTOMATIC CLOTHES WASHER SIMULATOR



The Omnidata model 101 serves to demonstrate the principles of operation and troubleshooting of a current-model, three-speed domestic, clothes-washing machine. Normal operation and 24 different malfunctions may be simulated.

The student's panel is a pictorial/schematic diagram equipped with pushbuttons, indicators, and controls. The diagram is carefully designed to associate the physical appearance of every part with its counterpart in an electrical schematic diagram. All operating controls of the actual machine appear on the simulator. Every setting of every control duplicates the conditions throughout the circuit of the actual machine under the same conditions. The pushbuttons are used to "replace" suspected defective parts. Visual aids are also provided in the form of appropriately illuminated indicators and transparencies.

The student's panel includes test points on "both sides" of every electrical part. In conjunction with a built-in multimeter, the student may measure normal (or abnormal) voltage or resistance readings between any two points in the machine under any combination of machine/malfunction control settings. Troubleshooting can be taught and practiced by voltage test methods, resistance test methods, or a combination of both.

FIGURE 33

MALFUNCTION LIST FOR SIMULATOR

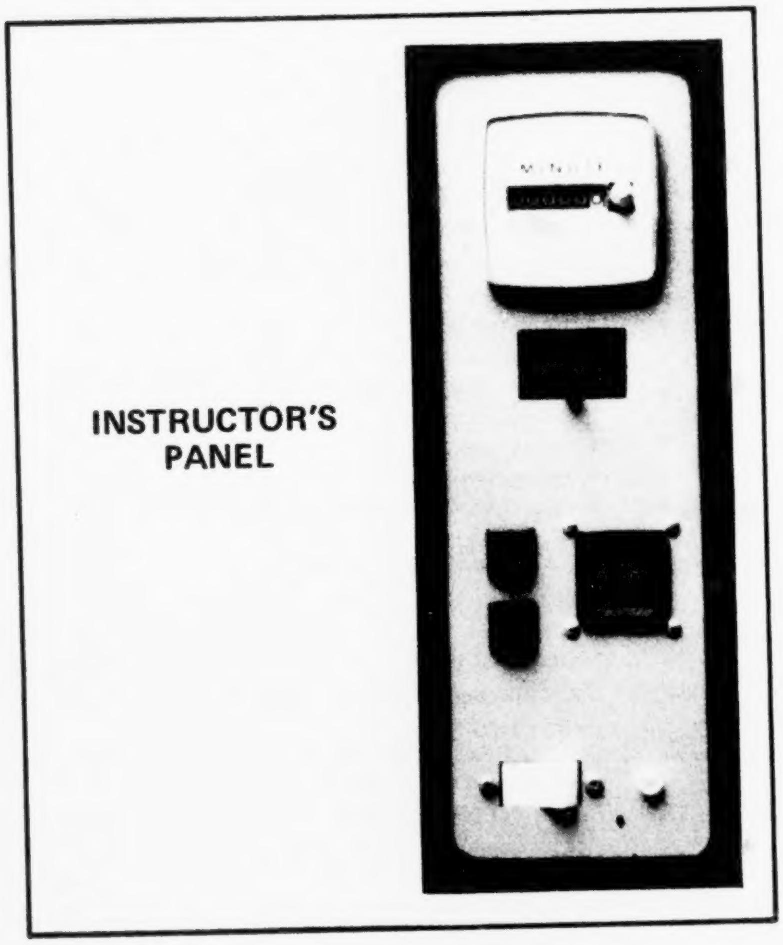
MALFUNCTION LIST

MALF. NO.	SYMPTOM	DEFECT	REPLACE NO.	ITEM
1	Fluorescent lamp does not light	Open light switch	4	Lamp switch
2	Fluorescent lamp does not light	Open ballast (choke)	2	Choke
3	Fluorescent lamp does not light	Open lamp filament	3	Fluorescent tube
4	Fluorescent lamp does not light and machine does nothing	Open motor protector	11	Motor
5	Fluorescent lamp lights and machine does nothing	Open ON/OFF switch	6	ON/OFF switch
6	Operation good until spin, then sequence stops	Open vibration limit switch	8	Vibration limit switch
7	No water enters tub	Open water level switch	9	Control pressure switch
8	No water enters tub	Open cam 10, bottom contacts	5	Timer
9	No water enters tub on hot wash	Open hot water solenoid	21	Water valve (solenoid)
10	No low speed agitation	Open agitate switch, low cont.	13	Agitate speed switch
11	No medium speed agitation or spin	Open motor, medium winding	11	Motor
12	No agitation at any speed	Open cam 3	5	Timer
13	No agitation	Open cam 4, bottom contacts	5	Timer
14	No agitation or spin	Open motor, direction winding	11	Motor
15	Operation sequence stops at end of agitate cycle	Open cam 7, top contacts	5	Timer
16	Operation sequence does not advance from any cycle	Open timer coil	17	Timer Motor
17	Bleach not added to wash	Open cam 6, top contacts	5	Timer
18	Tub empties, but basket does not spin	Open cam 8 contacts	5	Timer
19	Bleach not added to wash	Open bleach dispenser solenoid	15	Bleach dispenser solenoid
20	Wash water temperature ok, but rinse water always cold	Open rinse temperature switch	20	Rinse temperature switch
21	No agitation at any speed	Open water level switch	9	Control pressure sw.
22	No water enters tub on cold wash or cold rinse	Open cold water solenoid	21	Water valve (solenoid)
23	No water enters tub on hot wash	Open cam 11, top contacts	5	Timer
24	Operation good until spin, then sequence stops	Open door switch contacts	7	Door switch

FIGURE 34

INSTRUCTIONS PANEL FOR SIMULATOR

The instructor's panel includes an ON/OFF switch, an elapsed time indicator, a REPLACE counter, and "conditions controls" consisting of a two-digit selector switch plus INSERT and RESET pushbuttons. To operate, set the ON/OFF switch to ON. Normal operation will be simulated.



To insert a malfunction, set the two-digit selector switch to the desired malfunction (see malfunction list) then press the INSERT pushbutton. The elapsed time indicator will run and attempted repairs by simulated part replacement will be tallied by the REPLACE counter. When the proper part is "replaced", the elapsed time indicator stops and operation returns to normal. Any malfunction is immediately cleared when the RESET pushbutton is pressed. Both REPLACE counter and elapsed time indicator are manually reset at the indicator. One defective part is simulated by each position of the malfunction selector.

PERFORMANCE TEST

Transistor Receiver

This test is part of the package of electronics fundamentals material for the "Symprobe" simulator/trainer. The simulator uses removable schematic panels with programming cards to introduce malfunctions into the system. The examinee can determine signal condition (abnormal, normal, none) at test points on the circuit. He may also elect to determine voltage (low, normal, high) or resistence (low, normal, high). He can simulate the replacement of components to determine the effectiveness of his troubleshooting procedures.

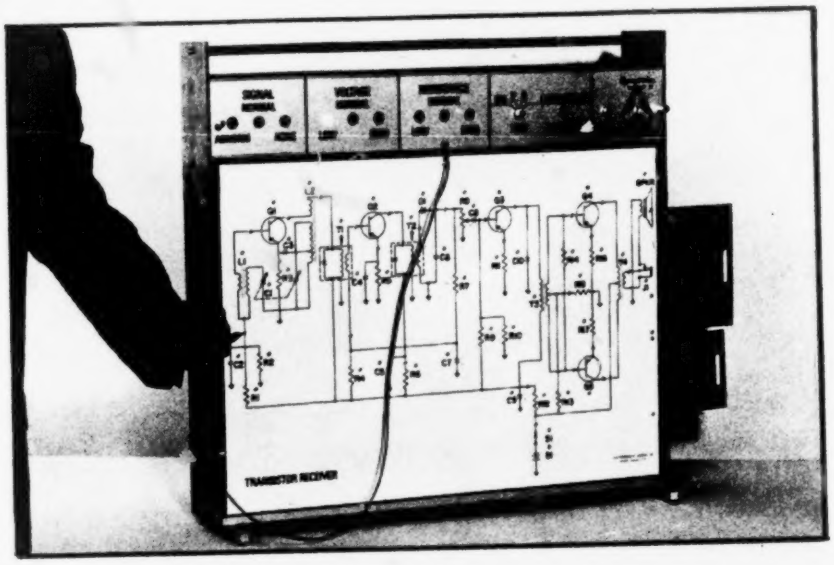
Materials for testing in other occupational areas--auto mechanics, air conditioning, hydraulics, pneumatics, and industrial controls--are also available.

The simulator is deficient in that the examinee is not required to read and interpret the voltage and resistance measurements and in the relatively small number of malfunctions that can be simulated.

Electromagnetic Sciences, Inc., Atlanta, Georgia

FIGURE 36

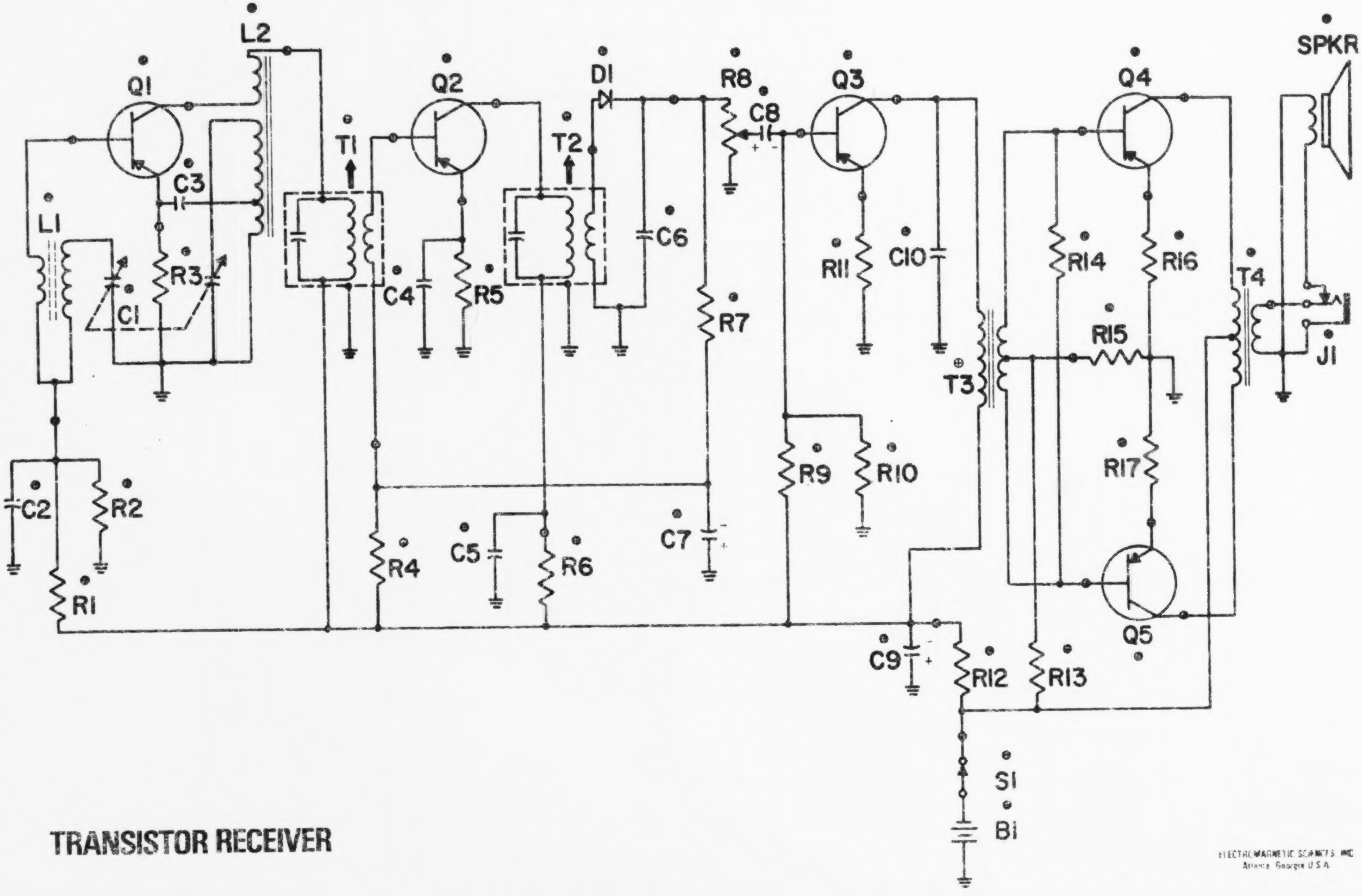
TRANSISTOR RADIO SIMULATOR



Programming Cards for Transistor Receiver:
(malfunctions that can be simulated)

1. Weak battery
2. Cracked ferrite loop antenna core
3. Defective on-off switch
4. Open decoupling capacitor in IF section
5. Defective AF output transistor
6. Open AGC filter capacitor

The examinee selects the test point and type of reading he wants, and records the results and sequence of steps on the Trouble-shooting Chart.


Q1
L2
Q2
D1
R8
C8
Q3
Q4
SPKR
L1
C3
T1
T2
C1
R3
C4
R5
C6
R11
C10
R14
R16
T4
R7
R15
J1
T3
C2
R2
R9
R10
R17
R1
R4
C5
R6
C7
C9
R12
R13
Q5
S1
B1

TRANSISTOR RECEIVER

ELECTROMAGNETIC SCIENCES, INC
Atlanta, Georgia U.S.A.

TRANSISTOR RECEIVER
TROUBLESHOOTING CHART

TEST POINT	SIGNAL			VOLTAGE			RESISTANCE		
	Abnormal	Normal	None	Low	Normal	High	Low	Normal	High
Q1 Base									
Bottom of L1									
Q1 Emitter									
Q1 Collector									
T1 Primary									
Q2 Base									
AGC Line									
Q2 Emitter									
Q2 Collector									
Top of R6									
T2 Secondary									
Detector Output									
Q3 Base									
Q3 Emitter									
Q3 Collector									
Top of R12									
Bottom of R12									
Battery Negative									
Q4 Base									
T3 Secondary C.T.									
Q5 Base									
Q4 Emitter									
Q5 Emitter									
Q4 Collector									
Q5 Collector									
T4 Secondary									

COMPONENT TEST

First Component Tested _____: Step No._____: Condition = Good_____; Replace_____.
Next Component Tested _____: Step No._____: Condition = Good_____; Replace_____.
Next Component Tested _____: Step No._____: Condition = Good_____; Replace_____.

PERFORMANCE TEST

Cosmetology

A subtest on general manicuring is shown, part of a comprehensive performance test in cosmetology. The "Performance Criteria" correspond to "Instructions to the Observer." The "Examination Instructions for Cosmetologists" parallel the "Instructions to the Examinee," and are given to the candidates prior to the examination day. The point values for each operation have been deleted from the "Rating Sheet." They normally appear in a column at the left of the sheet.

PERFORMANCE CRITERIA (Instructions for Examiner)

VIII. GENERAL MANICURING

A. Table Set Up:
   1. Correct implements and labelled supplies are set out on table: Clean towel is on table as arm rest for patron; manicure bowl containing warm soapy water and brush; wet sterilizer; emery boards; absorbent cotton, cuticle oil or cream, cutcile solvent, polish remover, liquid polish. Implements (steel file, cuticle pusher or knife, cuticle nippers or scissors, orangewood stick) are in wet sterilizer at beginning of manicure.

B. Filing and Shaping:
   1. Use of proper instrument (file or emery board) suitable for texture of nail.
   2. File held at proper angle (between 45° and 90°) under free edge.
   3. Filing without use of seesaw motion. (File moved from corner to center of nail only.)
   4. Ragged scarf under free edge of nail beveled.
   5. No filing deeply into corners.
   6. Nails all similar in shape. Nails filed the same length (where model's nails permit).
   7. Finished filing improves the appearance of the hand and nails.

C. Use of Orangewood Stick, Pusher, and Materials:
   1. Cotton tipped orangewood stick used to clean under free edge.
   2. Orangewood stick or sanitary dispenser used to apply cuticle softener to loosen cuticle (model's fingers should previously have been immersed in soap bath and nail brush used).
   3. Pusher properly used to loosen cuticle:
      a. Used with flat side of blade following curve of cuticle.
      b. Only square end of pusher used.
      c. Used with light pressure.
      d. Nail kept moist with cuticle solvent or soap bath during use of steel pusher.
      e. Dead cuticle is removed from nail plate
      f. Nail plate not scratched by pusher.

D. Proper use of nippers to trim cuticle: (Nippers must be used as applicants have been notified to bring model who will submit to modeling for all operations.)
   1. Held in proper manner to avoid cutting any skin around nail other than hang nails. Applicant must know how to adjust nippers properly.
   2. Nippers not pointed directly into flesh.
   3. Applicant improves nail by nipping:
      a. Does not ruff up more cuticle
      b. Rough places on cuticle are removed.
      c. Hang nails and callouses are removed from corners and grooves.
      d. Skin unbroken after nipping.
      e. Cuticle is free of snags.

E. Application of Liquid Polish:
   1. Polish is of applicable consistency.
   2. Polish smoothly applied on nails.
   3. No polish on skin or cuticle
   4. No polish underneath nails.
   5. Full nail body covered leaving hairline on free edge.

F. Sterilization of Instruments and Maintenance of Sanitation During Manicure

1. Appropriate implements are in sterilizer before beginning manicure. Implements kept in wet sterilizer when not in use. Implements should not touch towel before being used on cuticle or nail.
2. Table kept in orderly condition
3. Disposal unit used at all times
4. Emery board destroyed at completion of manicure

IX. PERSONAL APPEARANCE AND GROOMING

A. During the practical test the examiner will observe each applicant's personal appearance and grooming. Personal cleanliness, and neatness and cleanliness of hair, hands, nails and clothes will be the factors considered in rating personal appearance and grooming.

EXAMINATION INSTRUCTIONS FOR COSMETOLOGISTS

PLEASE READ CAREFULLY

1. All applicants must appear for the practical demonstration in white uniform. Female applicants must appear in full length, male applicants in jacket length, WITHOUT any mark of identification. The admittance card and the 5 x 3 inch photograph must be presented at the time of appearance.

2. It is the applicant's responsibility to appear at the practical demonstration with a female person who will submit to modeling for all operations of cosmetology as listed below, including a complete haircut. The model must appear with clean hair wearing appropriate clothing to allow for facial draping. We recommend that you have a model who has not served as a model in the last 30 days.

> CAUTION! If an applicant appears with a model who does not meet the above qualifications, it could prevent the applicant from demonstrating all the required skills and result in a failure of all or a portion of the examination.

Applicants are prohibited from using a model, any of the following: a person less than 15 years of age, a cosmetology student, an operator or instructor in cosmetology or any branch thereof licensed by this or any other State, cosmetology school owners or managers not otherwise licensed. Since many complications may arise, it is suggested that pregnant women not be used as models. The maximum time for drying hair after it has been cut, shampooed and set will be 45 minutes.

3. The applicant is responsible for appearing at the examination with a sufficient quantity of supplies, the required instruments in proper working order and sanitary condition, and patron protection drapings for the following operations: (Simulated material will be provided for cold waving, tinting and bleaching.)

Plain Facial
Eyebrow Arching
Facial Makeup
Cold Waving
Tinting and Bleaching
Haircutting and Shaping
Scalp Massage
Scientific Brushing
Wet Hairstyling
Combout
Manicuring

The following supplies and equipment are required:

Hair clamps, brushes, combs
Scissors and/or razor for
cutting and thinning hair
Shampoo, waterproof cape
Fingerwave lotion, hair net
Hairpins, bobby pins
Clippies, rollers

6 small cold wave rods,
12 medium cold wave rods,
12 large cold wave rods
Retention papers or crepe wool
Protective cream and cotton

Applicator bottles
Glass or plastic bowls
Swab and brush for tint and bleach
Sufficient clean towels

Antiseptic solution

Tweezers, cotton for eye pads
Solution for moistening eye pads
Cleansing cream, massage cream
Cleansing tissue
Astringent, spatulas
Powder base, cheek rouge, lip rouge
Eye shadow, mascara
Eyebrow pencil

Manicure bowl, manicure brush
Steel file, emery boards
Cuticle pusher
Cuticle nippers or scissors
Orangewood stick
Cuticle oil or cream
Cuticle solvent
Polish remover
Medium color liquid polish
Wet sterilizer

NOTE: Use of cuticle scissors or nippers must be demonstrated

RATING SHEET

DATE: ____________________

60 POINTS
45 PASSING

GENERAL MANICURING

IDENT. NUMBERS						
1. TABLE SET UP						
a. Required Labelled Supplies						
b. Implements in Wet Sterilizer						
c. Disposal Unit Available						
d. Polish Removed						
2. FILING AND SHAPING						
a. File Held at Proper Angle						
b. Moved from Corner to Center						
c. Shaped Nails Improved (as model's hands permit)						
d. Ragged Scarf Beveled						
3. USE OF ORANGEWOOD STICK AND PUSHER						
a. Cotton tipped orangewood stick used						
b. Flat side of pusher follows curve of cuticle						
c. Only spade end used, with light pressure						
d. Nail kept moist with solvent or bath						
e. Nail plate not scratched						
f. Dead cuticle removed from nail plate						
4. USE OF NIPPERS						
a. Adjusted and Held So Not Pointed Into Flesh						
b. Cuticle Improved (as hands permit)						
c. Skin Unbroken After Nipping						
5. APPLICATION OF LIQUID POLISH						
a. Applicable Consistency						
l. Smoothly Applied						
c. None Left on Skin						
6. MAINTENANCE OF SANITATION						
a. Table Kept Orderly						
b. Instruments in Sterilizer When Not in Use						
c. Disposal Unit Used						
Total Possible Score	60	60	60	60	60	60
Minus Penalty Points						
Applicant's Score						

Examiner's Signature ____________________

PERFORMANCE TEST

Plymouth Troubleshooting Contest

The Plymouth Troubleshooting Contest is a nationwide performance test administered to two-man teams representing their high schools or post-secondary schools. Specified tools and equipment are provided to the contestants; officials supply needed replacement parts. Each team works on a car which has had standardized maladjustments and malfunctioning parts installed. Scoring is on a time basis, with time penalties added to total repair time for faulty workmanship.

CHRYSLER - PLYMOUTH DIVISION
CHRYSLER
MOTORS CORPORATION

The Plymouth dealers of America and the Chrysler-Plymouth Division consider it a privilege to sponsor the Plymouth Trouble Shooting Contest. We gratefully acknowledge the cooperation and assistance of the educators throughout the United States who have made it possible for students to receive recognition for outstanding ability and performance in the field of Automotive Mechanics through their participation in the Plymouth Trouble Shooting Contest.

John H. Moore Jr.

JOHN H. MOORE, JR.
National Manager
Plymouth Trouble Shooting Contest

P. O. BOX 1658, DETROIT, MICHIGAN 48231

DESCRIPTION

The Plymouth Trouble Shooting Contest is a competition between schools offering a course in Automotive Technology as part of their curriculum.

Schools are represented in this contest by auto shop students who function as a two-man team. These teams compete against each other in diagnosing and correcting deliberately placed identical malfunctions in the electrical, starting, ignition, and fuel systems of Plymouth automobiles. In order to win the contest they are also required to take a written examination which is computed and applied as a factor in the judging process.

NOTE: Electrical system includes all safety items such as headlights, park and running lights, stop lights, windshield washers, windshield wipers, horns as well as all instruments.

Classifications are as follows:

** HIGH SCHOOL

** POST SECONDARY

QUALITY WORKMANSHIP

As the "Automobile Industry" keeps pace with the "Space Age" it becomes increasingly important that accuracy in workmanship be held to the highest possible degree of perfection. The more complex mechanisms of today's automobiles and the need for ever increasing awareness of safe operation of motor vehicles, require a degree of accuracy in workmanship that was unheard of a few short years ago.

Since the main goal of the Plymouth Trouble Shooting Contest is to interest and prepare students for rewarding careers in the Automotive Service Field we feel that all of us involved with the contest should continue to place emphasis on the importance of high quality workmanship.

By emphasizing the importance of accuracy now, you will influence the student's future attitude concerning workmanship regardless of his choice of vocations. However, we sincerely hope this choice will be in the Automotive Service Field.

GENERAL INFORMATION

The Rules and Regulations stated herein are presented for the purpose of establishing basic rules and guide lines to follow in conducting a Trouble Shooting Contest. These rules will not cover every situation that may be encountered during a contest. One of the responsibilities of the local Contest Committee will be to make local rulings that are not covered herein.

The Trouble Shooting Contest is a very important event to all people concerned and it is particularly important to the competing students, their instructors and their schools. Valuable scholarships and recognition are at stake so it is most important that a thorough job be done in communicating the rules and regulations to the students and instructors prior to the contest.

It must be clearly understood by all just exactly what is expected of them. This applies to specifications and quality of workmanship, just how the cars will be judged and the fact that the judge's decisions will be final.

All the malfunctions that will be planted in the vehicles will not be "typical" operating malfunctions, i.e., burned points, faulty condenser, shorted spark plugs, inoperative wiring, carburetion, etc. Since these are very difficult to duplicate in a natural way, malfunctions will be planted that will be artificial in nature -- in other words, man-made troubles instead of normal operating troubles.

It has been the experience of those who participated in past contests that, if theory is understood and a systematic diagnosis procedure is developed, any malfunction can be pin-pointed whether it happens naturally or is planted artificially.

After a contestant has located a point of trouble in a particular circuit he should not assume the balance of the circuit to be trouble-free. There may be several other malfunctions in the same circuit, which indicates that all contestants must check each section completely. The thoroughness of diagnosis cannot be over emphasized.

NATIONAL RULES FOR LOCAL CONTESTS

These rules apply to each local contest regardless of location. The below listed rules cannot be amended locally.

1. School officials and the automotive instructor will choose the contestants to represent their school on an "Intra-Class" competitive basis using methods at their discretion.

2. The automotive instructor will advise the local Chrysler-Plymouth Regional Office the: name, address, city, state, and date of birth of the team members at least ten (10) days prior to the contest, using the Advance Notification Form supplied by the Regional Office.

3. * The age limit for high school students will be that the student will not have reached his 20th birthday by July 1st of the calendar year of the contest.

4. * The age limit for post secondary students will be that the student will not have reached his 25th birthday by July 1st of the calendar year of the contest.

5. * Contestants in the high school classification must be undergraduates officially enrolled in a high school automotive shop class and be a 12th GRADE STUDENT.

6. * A high school student who is a Co-Op or D.O. type student must attend a minimum of one (1) period per school day of classroom study in Auto Mechanics in the school he will represent in the contest.

7. * Contestants in the post secondary classification must be full time students and be enrolled in an automotive shop class of a qualified post secondary school.

8. * A student that has participated as a high school or post secondary school team member in a LOCAL or NATIONAL Trouble Shooting Contest will NOT be eligible to compete in a contest again.

9. Each high school that has Automotive Technology as part of its curriculum may enter one team in a local contest.

10. Vocational Technical Centers, etc. may enter only ONE high school team regardless of how many outside schools they serve.

* See 27 "g" Page 171

11. Qualified Vocational Technical Centers, etc. may enter ONE high school team and ONE post secondary team if authorized by the appropriate Chrysler-Plymouth Regional Office.

12. ONE INSTRUCTOR will be allowed to accompany each winning team to the National Finals.

13. Parental Consent Forms must be submitted by all high school participants and by all post secondary participants that have not reached the age of 21 prior to the date of the local contest. Post secondary students over 21 years of age must sign the release portion of the form.

14. Identical malfunctions will be used in each contest.

15. No employee or an immediate relative (such as a son) of an employee of Chrysler Motors Corporation Sales and Service Divisions will be eligible to compete in a contest. (Any question on eligibility will be cleared in writing by National Headquarters.)

16. The maximum amount of test equipment that may be used in a local contest is as follows:

    1 - Volt Meter
    1 - Dwell Meter
    1 - Tachometer
    1 - Vacuum Gauge
    1 - Fuel Pressure Gauge
    1 - Compression Gauge
    1 - Timing Light -- (Appropriate adapter must be used at the distributor cap or spark plug. Sharp probes not permitted.)
    1 - Continuity Light
    1 - Remote starter switch or jumper wire

    SPECIAL NOTE -- There are no malfunctions used that require the use of an Ohm Meter. Any malfunction that is used that can be detected by an Ohm Meter can also be found by using a Volt Meter. OHM METERS ARE NOT ALLOWED.

17. When a team feels that their car is operating properly, and in accordance with prescribed specifications, they will signal their desire to make a road test and report to final judging by closing the hood.

18. The contest timer will record the time of hood closing and road test positions will be assigned in accordance with this time. No other timing method is authorized.

19. At the completion of the contest all instructors are responsible to see that the car their team worked on is in perfect running order and ready for return to the sponsoring dealer.

20. All local contests will have a time limit of one and one half hours. (1.5 hours)

21. Alternate instructors or students cannot participate in the National Finals without the written consent of the National Manager of Plymouth Trouble Shooting Contest in Detroit.

22. * To insure that all contest cars are in standard operating condition prior to the installation of malfunctions all cars that are used in a contest that were loaned to a school for practice will be assigned to that same school in the contest.

23. Prior to the contest the idle speed and dwell reading of a sample car at operating temperature will be set to specifications with a master tachometer and dwell meter. All participating schools will test their equipment on the car against this reading and calibrate their instruments accordingly. The appropriate meter readings will be posted on each team's meter(s) and on the Final Judges Sheet.

24. The Tac-Dwell unit used in the contest by each team will be used in the final judging of their car.

25. ** SCOUTING OF CONTESTS PROHIBITED. Members of participating schools (teachers or students) may not attend a contest in another area prior to his school participating in a local contest.

26. If the contest committee decrees that the mechanical portion of a local contest cannot be held or completed due to inclement weather and that the contest cannot be reasonably re-scheduled, all of the winning positions or any portion of the winning positions that have not been previously established will be determined by the written examination portion of the contest.

NOTE: ALTHOUGH CARS USED IN CONTESTS ARE NEW CARS AND HAVE BEEN CHECKED CAREFULLY FOR BEING IN STANDARD CONDITION IT IS POSSIBLE, AS WITH ANY PIECE OF MACHINERY, TO HAVE A FAILURE OVER WHICH NO ONE WOULD HAVE CONTROL. IF THIS SHOULD OCCUR, IT WILL BE CONSIDERED UNAVOIDABLE AND PARTICIPANTS WILL BE EXPECTED TO ACCEPT THIS WITHOUT CLAIM OR RECOURSE.

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* See 27 "f" Page 171

** See 27 "b" Page 171

TEAM RULES AND INSTRUCTIONS

1. All participating schools agree to abide by the rules as outlined in this booklet and any amendments other than to the National Rules as outlined by the Contest Committee.

2. School Application Forms shall be filled out and returned to National Headquarters post marked no later than the date specified on the Application Form.

3. Immediately upon arriving at the contest site the school instructor will report to the registration desk. He will present the completed Parental Consent and Release Form for each of his team members and will report changes in the status of his team members, if any.

4. All malfunctions will be placed under the hood. It is not necessary for team members to work under the dash, car, or in the trunk.

5. Local contests will use current model Plymouth cars which should be the same car line equipped with the same type engine and basic equipment.

6. The school instructor is responsible for having the team suitably dressed in shop coats, coveralls, etc.

7. Each team must supply two (2) seat covers.

8. Each team must supply a CO2 fire extinguisher.

9. Each team must supply their own test equipment, and standard hand tools, sockets, etc., sufficient to handle the normal tune-up on current model Plymouths. Test equipment shall not exceed that shown under "National Rules." A flat portable tray, flat stand, or card table may be used to support tools during the contest. Vises or other means used to support carburetors or distributors cannot be used except those that may be furnished by the Chrysler-Plymouth Regional Office.

   NOTE: Standard hand tools are considered those that are available on the open market from nationally recognized tool manufacturers and their sales outlets.

10. Students will be advised when to place their tools and equipment in front of their assigned car prior to the start of the contest by the contest manager. They will not enter the contest area prior to this for any reason.

11. The necessary parts to assist in correcting the malfunctions will be available from the team judge. The deficiency of parts the team desires to replace must be reasonably described before a new part can be obtained.

12. A parts department will be established at the contest site to supply parts that are not involved in the malfunctions that are inadvertently broken or lost. The Contest Committee does not guarantee the availability of all such parts, therefore, careful workmanship is mandatory.

13. Complete carburetors, distributors, fuel pumps, etc. cannot be substituted.

14. Permission to go to the parts department for any part must be granted by the team judge.

15. * No spare parts other than those issued directly to a team member by the official parts department are allowed in the possession of a team member. This includes in tool box or on person.

16. When the team members feel their car is ready for road testing it is their responsibility to alert their team judge of their intentions prior to closing the hood to assure accurate timing.

17. Each vehicle must be in such condition that it can be satisfactorily operated and the engine must run and idle smoothly in accordance with standards described prior to the contest by the Contest Committee's spokesman at the briefing.

18. During the test drive the vehicle will be driven by one of the team members (having a valid driver's license) around the track in the direction requested by the team judge. The team judge will ride in the front seat while the other member of the team rides in the rear seat. If neither team member has a valid driver's license the TEAM JUDGE will drive on the road test and one member will ride in the right front seat.

19. The vehicle must be driven around the course prescribed at speeds not to exceed 30 miles per hour or any posted speed below 30 miles per hour for safety reasons.

20. Stall testing will not be allowed in the contest area or test track. This is a dangerous practice and not recommended as an engine test procedure.

21. In the event that a team starts around the prescribed course and the engine should die and cannot be restarted with the starter from within the vehicle the team will be automatically disqualified.

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* See 27 "e" Page 171

22. There will be no passing on the track unless there is a stalled vehicle on the test track that has been disqualified then the team judge will direct the driver to pass.

23. During the test drive if the team members feel that the car is not operating properly, prior to crossing the finish line, the car may be returned to the work stall assigned to them for further repairs. If they feel the car is operating properly and will pass inspection they may cross the finish line and report to the final judging area. The responsibility for making the final decision whether to return to the work stall or report to final judging will be the team member that drives the car on the road test. However, if Rule No. 18 above applies the team member that rides in the front seat will make the decision.

24. The final judging area will be available to the final judges, the two team members and the team judge only. Both team members will remain with the car as directed by the chief final judge.

25. Smoking will not be permitted in the work or judging area at any time by contestants for safety reasons.

26. Safety glasses furnished will be worn by all contestants during their work on the cars. (We realize this may not be a regular practice for mechanics but in a contest the team members are working fast and under pressure and with the possibilities of back-firing, etc. this safety precaution is necessary).

27. TEAMS WILL BE DISQUALIFIED FOR THE FOLLOWING REASONS:

    a. Failure to follow rules and regulations or the team judge's instructions.

    b. Scouting other contests.

    c. Violation of common safety rules and/or endangering team-mates through carelessness.

    d. Conduct on the part of the instructor or students unbecoming a gentleman or to the spirit of the contest and the school they represent.

    e. Having parts in their possession not issued by the team judge or official parts department.

    f. "Marking" of any part or unit prior to delivery of the contest car to the contest site.

    g. Ineligible team member.

CONTEST COMMITTEE

Local contests will be operated under the direction of a Contest Committee which should be composed of at least one member from education, one member from the Plymouth dealer organization, and one member from the Chrysler-Plymouth Regional Service Department.

The chairman should be the educator selected and he will speak for the Committee after arriving at decisions.

The responsibilities of the Contest Committee are as follows:

1. Designate the contest location, date, and time.
2. Determine the malfunctions to be used in the contest.
3. Establish a malfunction installation procedure that will asure uniformity of all contest cars. (Make up check off sheet.)
4. Establish workmanship quality standards and specifications which must be met to qualify as a winner.
5. Will appoint:
    1. Contest Manager
    2. Official Timer
    3. Line Judges
    4. Team Judges
    5. Final Judges

    NOTE: Final judges in most cases will include a member of the Contest Committee
6. Make certain that each car is inspected and is in standard operating condition prior to the installation of malfunctions.
7. All judges will be thoroughly briefed on their responsibilities by a person appointed by the Contest Committee prior to the start of the contest, including a review of all malfunctions that will be used in the contest.
8. Any rule additions approved shall be reviewed carefully with all participating judges, instructors, and students prior to the start of the contest so that there are no misunderstandings. Any infraction of the rules and regulations or disputes which may arise during these contests will be reviewed and a decision made at the time by the Contest Committee and announced by the chairman. This decision WILL BE FINAL.
9. Carefully review with all participants the standards and specifications established for final judging.

CONTEST MANAGER

The contest manager will be responsible for the overall operation of the contest.

His duties are as follows:

1. Supervise the pre-malfunction check of all contest cars.
2. Supervise the numbering and placement of all cars at the contest site.
3. Supervise the installation of the malfunctions in all contest cars as established by the contest committee.
4. Establish a road test route and finish line (point of no return.)
5. Designate the location and supervise the setting up of a pre-contest team tachometer and dwell meter testing area and the final judging area.
6. Make arrangements for a suitable place for all contestants to take the written examination.
7. Appoint a person to administer the written examination. (Note: that person will be responsible for computing the examination value and will enter the results on the Final Judging Form.)
8. Designate a spare parts department area and appoint a parts manager.
9. Designate a location for cars to be restored to standard condition that have been judged and deficiencies found. Corrections are to be done by the team members.
10. Will point out the road test and final judging areas during the pre-contest briefing.
11. Will introduce the final judges during the team briefing and give a brief description of each ones qualifications.
12. Be responsible for the proper start and finish of the contest.
13. Supervise the activities of the contest timer, line judges, team judges and final judges.
14. Direct cars to enter the test track in accordance with the time of hood closing and control traffic flow during test drives.
15. Prior to announcing the winners he will review the official judging forms on all teams that were judged with the official timer and the final judges and will make certain all entries are correct.

CONTEST TIMER

1. Make certain each team instructor confirms the accuracy of his team's Registration Form.
2. Assign a team number to each competing school that corresponds with their car number and advise each team accordingly.
3. When the starting signal is given he will enter the starting time on the Official Time Record Sheet.
4. Keep in constant contact with the line judges and when a team closes the hood indicating they have finished, will record the time of hood closing on the Official Time Record Sheet.
5. Should a team reopen the hood prior to leaving the work area or should a team elect to return to the work area, the previously recorded finish time shall be disregarded and the elapsed time will continue from the original starting time of the contest.
6. As each team commits to final judging he will transfer the official elapsed time from the Official Time Record Sheet and enter it on the Official Judging Form.
7. Will turn the Official Judging Form over to the team judge after the official finish time has been recorded and upon his request.
8. When the contest is officially over will turn all the remaining Official Judging Forms over to the Contest Manager.

LINE JUDGE

A line judge will supervise the activities of the team judges. This should not exceed ten (10) teams. His duties are as follows:

1. Be alert at all times to see that all team judges under his control remain in his assigned area and complies with all requirements as listed under "Team Judge", especially items number 1, 2, and 10.
2. Continuously be in contact with the team judges and assist as may be required. When he is signaled by the team judge that a team is about ready to close their hood, he will alert the contest timer so that the team may be accurately timed.
3. Assist the contest manager in maintaining an orderly traffic flow onto the test track.
4. At the conclusion of the contest will make certain that the team judges and instructors of all remaining cars in his area assist the contestants in putting their car in standard operating condition for return to the sponsoring dealer.

TEAM JUDGE

A team judge will officiate for one team only. If he represents a Plymouth dealer or competing school he will not be allowed to officiate a team he represents. (The team judge's duties are as follows:)

1. See that the team's fire extinguisher is accessible.
2. Make certain that all contestants are wearing safety glasses.
3. See that the contestants do not attempt to enter or inspect the vehicle before the starting signal is given.
4. Will check their team's tools and equipment and if any unauthorized or doubtful items are in their possession report the fact to the contest manager.
5. Be familiar with all parts that are in the team judge's parts box and will have each replacement part readily available upon request. Every precaution is to be taken not to reveal other parts that are in his possession.
6. If the part requested is malfunctioned he will require a reasonable description of what is wrong with the part. (Open circuit, shorted, etc.)
7. * Will report to the contest manager immediately any spare parts found in the possession of a team member.
8. Will issue only ONE part at a time.
9. If a part is requested that is not a part of the contest he will require the team member to give a reasonable explanation of what is wrong with the part. After listening to his reason for wanting to replace the part will advise him he does not have one. If the team member still insists there is something wrong with the part he is to be advised he should request the part at the Central Parts Department.
10. Observe the progress of repairs but will not interfere with the team unless such repairs are damaging to the vehicle or to the safety of the contestants.
11. Will not assist the team in any manner in locating or correcting malfunctions during the contest.
12. Upon being alerted by the team members they are preparing to close the hood will alert the line judge to the situation.
13. At the moment of hood closing will signal the line judge and timer that his team is finished.

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14. Will not allow the car to be moved out of the stall until signaled by his line judge.

15. Will make sure that the test driver has a driver's license. Will be seated beside the team driver and will direct the course the driver should follow after release by the contest manager. During the test drive he will be sure that the speed limit is observed and no passing allowed except in the case of a stalled car on the test course. If neither team member has a valid driver's license the team judge will drive the car on the road test. He will not express an opinion at any time whether or not the car is operating properly.

16. When the team successfully completes the course and crosses the finish line he will direct the team driver to the area designated for final judging, have him park the vehicle and TURN OFF THE ENGINE.

17. After the car is parked in the final judging area, will immediately report to the contest timer and secure the official judging form and return to his car and give the official judging form to the chief final judge. He will then remain with the team until officially released.

18. After winning teams are selected, and at the contest manager's direction, team judges will assist the remaining contestants and the school instructor in correcting malfunctions in their vehicle and will not leave until the car is in standard operating condition.

FINAL JUDGES

1. There shall be a minimum of two (2) qualified persons appointed as final judges by the Contest Committee. The spokesman for the final judging team should be selected and he should be introduced during the team briefing session as the Chief Final Judge.

2. Prior to the contest and prior to the final briefing of contestants and instructors, the final judges will review workmanship standards and tune-up specifications that will be used in the judging of cars.

3. As soon as a team enters the final judging area the Chief Final Judge will direct the team judge to proceed to the timing stand and secure that particular team's final judging form.

4. The final judges will follow the official judging form and check each item for all previously prescribed standards of workmanship and engine performance. Each car will be carefully evaluated and if found to be up to standard the right hand column of the Official Judging Form will be checked. If an item does not meet the standards set, the penalty minutes figure will be circled.

5. A road test of the car by the final judges is at their option.

6. After all eligible cars are judged, the final judges will total all items in the lower right corner of the Official Judging Sheets and will double check and review all forms with the contest manager.

SPECIAL NOTE

A SAMPLE OF THE OFFICIAL JUDGING FORM IS SHOWN AT THE RIGHT. PLEASE NOTE THAT THE SMALLEST PENALTY THAT WILL BE ASSESSED FOR SUBSTANDARD WORKMANSHIP IS A TEN MINUTE DEMERIT. THIS MEANS THAT A TEAM THAT FINISHES WITH A PERFECT CAR (NO WORKMANSHIP PENALTY MINUTES) CAN CLOSE THEIR HOOD NINE MINUTES AND FIFTY-NINE SECONDS AFTER A TEAM THAT INCURRED ONE TEN MINUTE PENALTY AND STILL BEAT THEM, ASSUMING BOTH TEAMS HAD THE SAME SCORE ON THE WRITTEN EXAMINATION.

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84-325-0398 (10-69)

OFFICIAL
PLYMOUTH TROUBLE SHOOTING CONTEST
REGISTRATION AND JUDGING FORM

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CHRYSLER-PLYMOUTH REGION ____________ **CONTEST CITY** ____________ **DATE** ____________

High School ☐ **Post Secondary** ☐

____

School Name Street Address City & State

Team Number ____________

		Workmanship Demerit Minutes	Inspected
1.	Any malfunction left in (that is malfunctioning)	**Disqualified**	
2.	Carburetor air cleaner, gasket, vent assy. & all hoses (each)	( ) 10	
3.	Distributor point dwell ________ (SPECIFICATION) ________ (ACTUAL) vacuum hose off (each degree out of specification)	( ) 30	
4.	Engine idle ________ (SPECIFICATION) ________ (ACTUAL) vacuum hose off – Transmission in neutral Correct to + or – 30 R.P.M.'s Correct to + or – 31-50 R.P.M.'s Correct to + or – 51-70 R.P.M.'s Correct to + or – 71 and over R.P.M.'s	 0 10 20 30	
5.	Ignition timing ________ (SPECIFICATION) ________ (ACTUAL) vacuum hose off Correct to + or – 1° Correct to + or – 1° to 2° Correct to + or – 2° to 4° Correct to + or – 4° and over	 0 10 20 30	
6.	Leaks in fuel system, fuel pump inlet to carburetor base (any amount)	( ) 20	
7.	Carburetor, linkage, and all vacuum hoses installed properly (each)	( ) 10	
8.	All wires and cables routed & installed properly (each)	( ) 10	
9.	Oil, fuel, heat & ampmeter guages or lights connected & reading properly (each	( ) 10	
10.	Distributor, coil, starter relay & ballast resistor installed properly (each)	( ) 10	
11.	Engine idles smoothly	( ) 10	
12.	Lights - Head, Park, Stop, Back-up, & Turn Signals not working (each)	( ) 10	
13.	Windshield wiper Windshield washer not working (each)	( ) 10	
14.	Jumper wire, timing light adapter or hand tools left under hood (each item)	( ) 10	

WORKMANSHIP PENALTY MINUTES ____ : ____

TIME TO CLOSE HOOD ____ : ____

WRITTEN EXAMINATION DEMERITS ____ : ____

GRAND TOTAL ____ : ____

Minutes : Seconds

FINISH POSITION

☐ **First** ☐ **Second** ☐ **Third** ☐

REMARKS: ____

____

Chief Final Judge ____________________
Signature

JUDGING SHEET – REGIONAL OFFICE

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